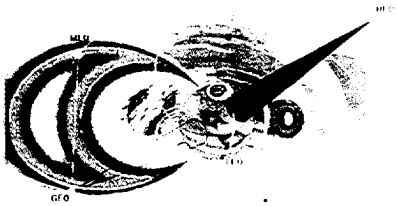

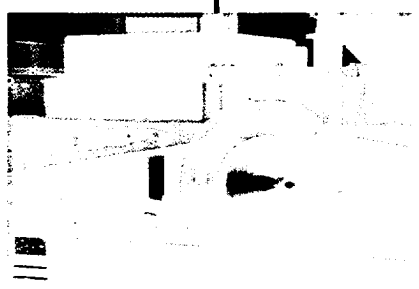

Air Force Research Laboratory
SUCCESS Stories

A Review of 2002

To receive more information about any of the success stories in this book or on the CD-ROM, or other technical activities in Air Force Research Laboratory, contact TECH CONNECT at (800) 203-6451.

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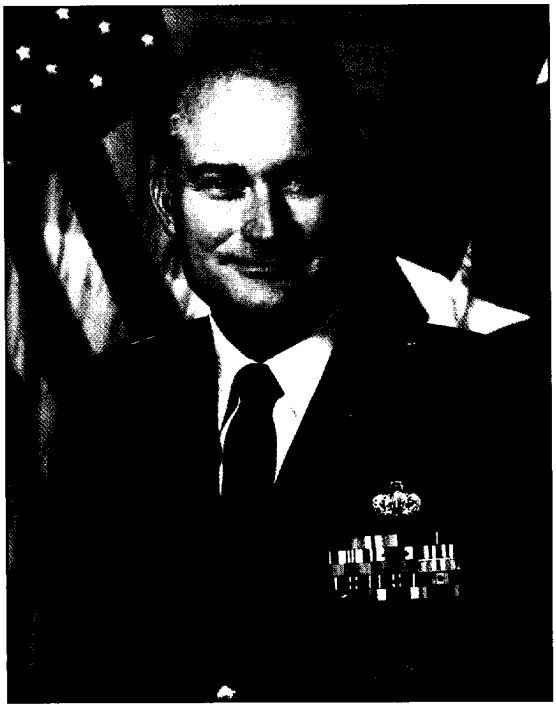
AFRL Success Story Program

Helping to maintain the Air Force's strong Science and Technology foundation one success at a time.

With a team of more than 5,200 scientists, engineers, and support personnel worldwide, the Air Force Research Laboratory is one of the most exciting organizations in the Air Force. AFRL team members are up close and personal with the discovery, development, and integration of cutting-edge technologies for today, tomorrow, and well into the future.

AFRL is headquartered at Wright-Patterson Air Force Base, Ohio and is the Air Force's largest employer of scientist and engineers—about 3,000—of which more than 800 have doctorate degrees in science and engineering disciplines. These highly skilled and motivated people are critical in leading our government-industry-university team and in making technological and scientific breakthroughs. Our scientists and engineers push the limits of air and space, bringing critical technologies forward into the realm of application.

This world-class laboratory harnesses the innovative ideas of the best minds in government, industry and academia to create the future of the Air Force. The men and women of AFRL defend America by unleashing the power of innovative science and technology.



AFRL Success Stories highlight the cutting-edge research performed within the laboratory. The following pages feature some of our most noteworthy successes during 2002. These stories are just the "tip of the iceberg" of AFRL technologies currently under development. There is an accompanying transportable CD-ROM that demonstrates the same information showcased in this book.

If you want to know more about a success story, please contact our technology clearinghouse, TECH CONNECT, at (800) 203-6451, and they will direct you to the appropriate laboratory expert. Visit our website at *www.afrl.af.mil*.

Introduction

The Air Force Science and Technology Success Stories herein often represent the combined effort of several scientists and engineers working as a team. The basic and applied research, plus the follow-on technology development described, are essential to the continued success of the Air Force mission.

Success Stories were selected from one or more of the following categories:

Support to the Warfighter

Technology that has potential for or has achieved application on a Department of Defense system in development or operation or that has provided "quick-reaction" response to problems or needs of field organizations.

Major innovative technological advancements that offer significant potential for existing and future Air Force systems.

Technology Transfer

Technology that has transferred from the laboratory to the private sector, to include industry, academia, and state and local governments.

Awards/Recognition

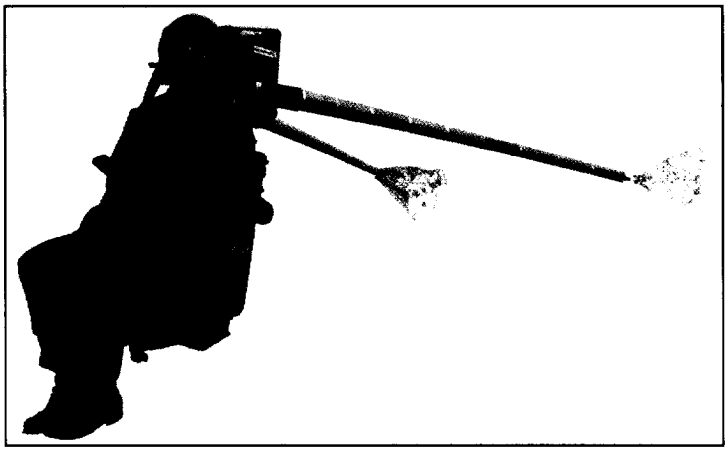
Awards or recognition by the scientific community at large, concerning technology advancements in the areas of technology transition, technology transfer, or technical achievement.

Support to the Warfighter

Demonstration of a US Version of the Lightweight Russian K-36/3.5 Ejection Seat

Payoff Demonstrations show the United States (US)-equipped K-36/3.5 ejection seat to be an affordable ejection seat option with unparalleled safe escape capability. With redesigned pyrotechnics and electronics, the Russian lightweight K-36/3.5 ejection seat accommodates the full (expanded) size and weight ranges of US aircrews; enhances low-altitude, adverse-attitude ejection performance; and provides high-speed escape capability up to 700 knots equivalent airspeed.

Accomplishment The Human Effectiveness Directorate recently completed an advanced development effort to design and demonstrate pyrotechnics and electronics for a Russian-made lightweight K-36/3.5 ejection seat. This effort ultimately met the demanding US requirements such as a greatly increased pilot population, more severe operational environments, and increased reliability, without increasing the system weight or the performance intended by Russian designers. The US-equipped K-36/3.5 ejection seat was renamed the K-36/3.5A.



Background The Russian lightweight K-36/3.5 ejection seat deploys a unique stabilization system of telescoping booms by the time the seat leaves the cockpit. The ejection seat integrates subsystems such as leg lifters, leg and arm restraints, windblast protection, and a vented helmet designed to interface with the seat headrest.

This effort required US manufacturers to design propellant charges to ensure safe escape during emergency conditions for extremes in US pilot population from small 103-pound to very large 245-pound aircrew. The manufacturers also designed new initiating devices and propellants to avoid premature ignition during US operations. New initiating devices and propellants include higher electromagnetic interference from radar emissions and the ability to operate reliably at temperature extremes of 65° hotter than the Russian-designed maximum.

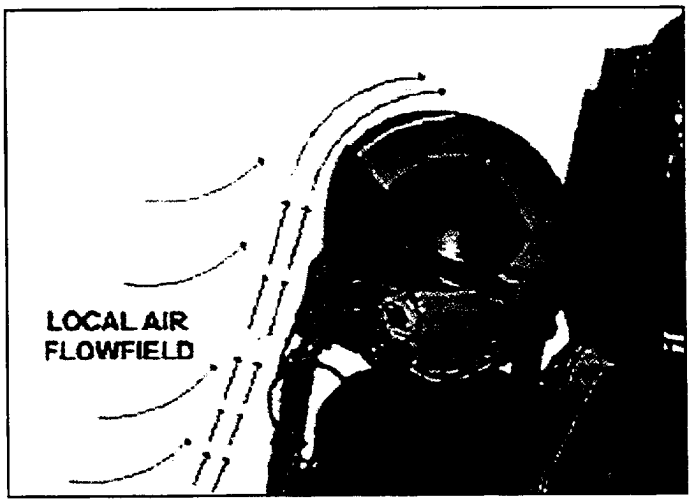
The manufacturers redesigned the electrical systems, including the signal conditioning and sequencing systems, to eliminate single point failures and use a seat-mounted power source. The directorate conducted system level verification tests to demonstrate that the US version maintained the performance of the Russian version. US-manufactured energetics maintained the demonstrated capabilities of the Russian-made K-36/3.5, making it an affordable ejection seat option that provides safe escape for all aircrew members throughout current fighter aircraft flight envelopes.

Demonstration of a Modified HGU-55/P Flight Helmet

Payoff A Human Effectiveness Directorate-modified HGU-55/P flight helmet decreases major injuries and fatalities caused by windblast forces in the head/neck area for crewmembers ejecting at airspeeds higher than 350 knots equivalent airspeed (KEAS).

Accomplishment Directorate engineers successfully completed an advanced development effort that reduced excessive aerodynamic loading of United States Air Force (USAF) flight helmets with minor modification. The demonstrated low-cost field modification to the HGU-55/P flight helmet and visor allows the aircrew member to safely retain his/her helmet up to 600 KEAS.

Background The current lightweight USAF HGU-55/P flight helmet's visors with elastic retention straps are not adequate to ensure retention of the visor at ejection speeds above 350 KEAS. Directorate engineers designed a simple, low-cost modification to the elastic strap, helmet, and visor to lower the aerodynamic loads on the aircrew member's head and neck while keeping the visor in place.



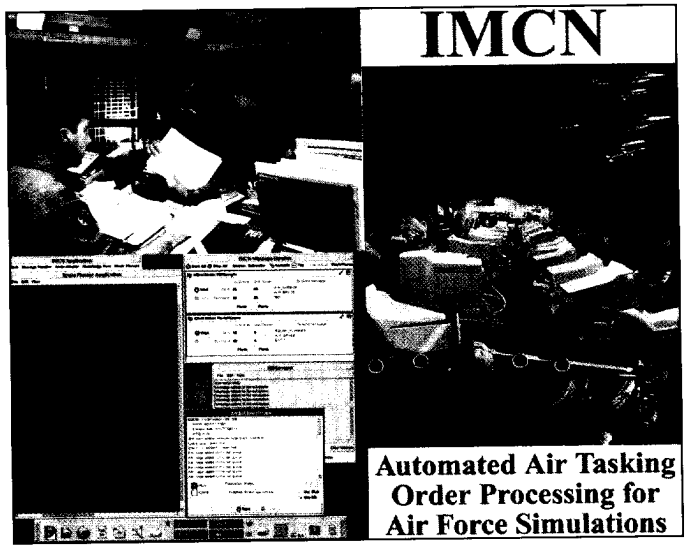
Engineers demonstrated the effectiveness of the design during windblast tests up to 600 KEAS. The functional utility of the helmet and visor was retained, including the ability to change the visor in flight.

Life support personnel can implement the modification in the field with standard shop tools. The reduced aerodynamic loading and retention of the helmet and visor will decrease head and neck injury potential during emergency escape.

AFRL Technology Enhances Realism of Combat Exercises

Payoff The Intelligent Mission Controller Node (IMCN) increases the realism and reduces the cost of air combat command and control simulations, specifically Joint Training Confederation exercises of today and Joint Simulation exercises of tomorrow. This technology automates the Air Tasking Order translation and modification process, allowing exercises to be conducted with fewer technical controllers.

Accomplishment The Human Effectiveness Directorate's Deployment and Sustainment Division transitioned the IMCN software toolkit to the Air Force Integrated Command and Control System Program Office. The toolkit dramatically improves the training value and efficiency of command post exercises, while simultaneously reducing their cost. IMCN is a valuable addition to the warfighter's modeling and simulation toolkit, and warfighters use it in a widening array of exercises to increase their effectiveness and affordability.



Background Directorate engineers developed the IMCN toolkit over the past 2 years with co-funding from the Defense Modeling and Simulation Office and the Office of Naval Research. Recently, the IMCN successfully passed a number of demonstration trials, and the Air War Simulation and National Air and Space (Warfare) Model programs accepted it for transition.

CAESAR Revolutionizes Product Design and Manufacturing

Payoff The Human Effectiveness Directorate's Civilian American and European Surface Anthropometry Resource (CAESAR) provides accurate three-dimensional (3-D) human models and body measurement data for the improved design of systems, equipment, and clothing for warfighters as well as civilians.

Accomplishment CAESAR uses 3-D scanning to remove the guesswork in human physical measurements. Since humans are 3-D, as are the products they use and wear, 3-D is vital in design. Traditionally, researchers used one-dimensional (1-D) body measurements, such as chest circumference, waist circumference, and arm length, to create 3-D human models; no other way existed to create the whole person in 3-D.

CAESAR's 3-D scans provide the complete 3-D person. It provides over 13,000 3-D electronic human models as well as 99 traditional, 1-D body measurements. More accurate 3-D models can save time and money formerly spent to make 3-D models from 1-D data.

With the capability to improve product designs, CAESAR allows researchers to design and tailor systems and equipment in order to accommodate different body shapes and sizes. Industry could use CAESAR as an effective, efficient way to design and manufacture products, such as automobiles, airplane seats, furniture, sports equipment, clothing, or artificial limbs, that better fit the variability of body shapes and sizes.

Background CAESAR, a 10-year effort within the directorate's Crew System Interface Division, is the technological brainchild of Ms. Kathleen Robinette, AFRL anthropologist and director of the Computerized Anthropometric Research and Design (CARD) Laboratory. Ms. Robinette recently earned the Good Housekeeping Award for Women in Government for her work with CAESAR.

Technologies pioneered in CARD, such as the first human head scanner and a whole-body scanner, helped launch CAESAR as the first successful 3-D surface anthropometry survey. The survey obtained body measurements of 4,431 civilians, 18 to 65 years old, from the United States, The Netherlands, and Italy—countries whose populations are among the largest, tallest, and shortest in the North Atlantic Treaty Organization, respectively.

ACCES Enhances Voice Communication and Safety

Payoff The Attenuating Custom Communications Earpiece System (ACCES), developed by the Human Effectiveness Directorate and Westone Laboratories, delivers clear voice communication clarity with improved hearing protection for personnel working around high-performance aircraft at high-power settings. ACCES provides a solution to a long-standing ground safety deficiency associated with tactical fighter aircraft sustainment.

Accomplishment Safety issues arose as F-22 jet noise above engine idle impacted voice communication clarity from Raptor test pilots to their crew chiefs and maintainers. Conventional military communication headsets did not generate clear audio signals in high-noise environments, and ready-made, off-the-shelf products could not resolve the problem.

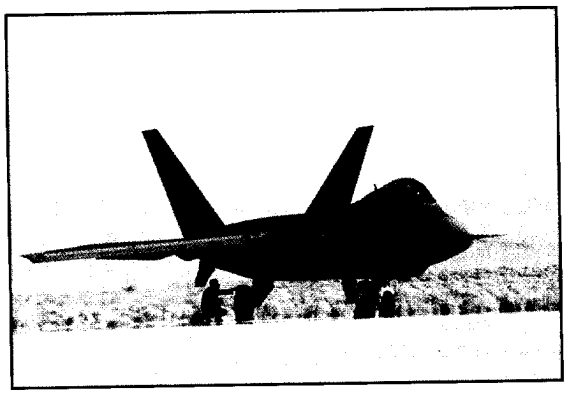
The Air Force requirement to wear earplugs under the headsets on the flightline (for maximum noise protection) further complicates the issue. However, ACCES solves this problem by delivering communication through a hearing protection earphone customized for each user.

Made from maintainers' ear casts, the earphone has a high-fidelity miniature receiver deeply embedded within each earpiece. Combined with the embedded receiver, ACCES permits a robust, high-fidelity speech signal from the miniature loud speaker—even in noise environments as loud as 150 decibels.

ACCES has flexible functionality. The customized design permits deeper ear insertion than that of conventional earplugs, and maintainers can wear the earpiece under chemical/biological protective suits for clear, uninhibited communication.

Furthermore, maintainers can even wear ACCES under conventional headsets, alone when noise levels permit earplug use only, or plugged into the helmet or headset when noise levels increase and requirements change to double hearing protection. ACCES achieves double hearing protection and, over time, achieves protection at a cost much lower than that of today's disposable, one-size-fits-all generic earplugs.

Background Directorate researchers conducted highly successful field demonstrations with ground crews in 2001. A field study of an improved ACCES prototype yielded similar success. Engine test cell crews also experienced great results. ACCES demonstrates significant advantages concerning ground safety and auditory protection for military aerospace operations.



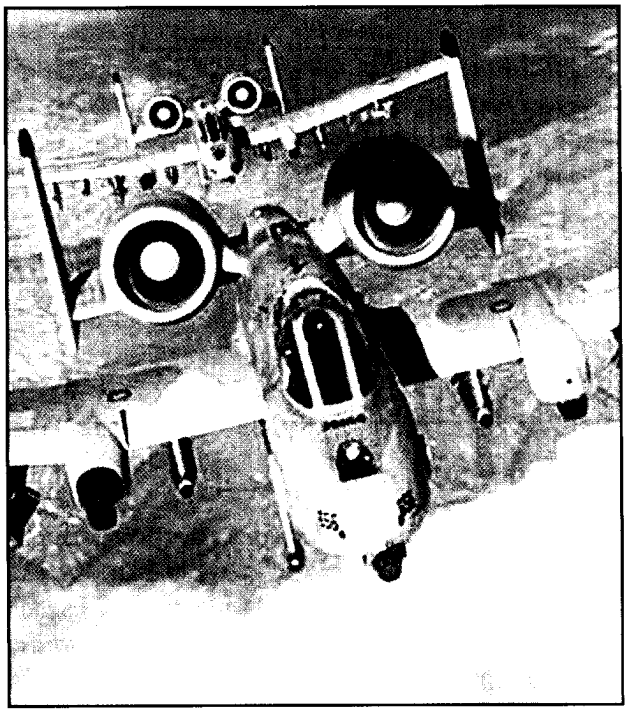
Directorate researchers conducted controlled lab tests of ACCES speech intelligibility performance and noise attenuation. They will work to combine ACCES with active noise reduction, further enhancing its voice communication delivery and noise protection qualities.

Fatigue Countermeasures Support for Operation ENDURING FREEDOM

Payoff In response to over 20 different requests, Human Effectiveness Directorate researchers provided American warfighters the knowledge and techniques to counter fatigue during Operation ENDURING FREEDOM (OEF). Contributions from the directorate's Warfighter Fatigue Countermeasures (WFC) program at Brooks Air Force Base, Texas, were essential in helping OEF warfighters overcome fatigue—an insidious, pervasive, and ubiquitous enemy of global military operations.

Accomplishment Directorate researchers provided operational wings, maintenance, security forces, information operations, and medical support organizations with the essential science-based expertise, software tools, and fatigue management recommendations to endure and quickly recover from fatigue during OEF operations. The application of knowledge and products from the WFC program reduced fatigue-induced performance decrements and improved operational risk management, contributing to the reduction of non-combat injuries and casualties. Warfighter feedback cited improved mission effectiveness and morale as specific benefits resulting from these WFC consultations.

Background The WFC Research Team's excellent relationship with the warfighter and support communities for the past 30 years is largely due to the timely and accurate delivery of fatigue countermeasure products tailored to enhance warfighter performance in specific operational environments. The inclusion of WFC scientists flying with the aircrew members during simulated and actual missions enables an extraordinarily tight spiral development.



The WFC Team equipped American warfighters to successfully execute long-duration missions in hostile territory. B-2 pilots reported successful cognitive performance and vigilance during the 44+ hour OEF missions. They used WFC guidance during 50-hour simulator missions to assess the efficacy of using the alertness aid Dextroamphetamine prior to key mission events.

Other applications include shiftwork scheduling for information operations and security forces personnel, mission planning for A-10 global deployments, and assessment tools for quantifying crew fatigue in C-17 long-haul flights. The application of WFC research and scientific expertise directly enhanced the effectiveness of air, ground, and support operations during OEF.

AFRL Develops Flexible Decision Support Tools for Intelligence and Command and Control

Payoff The Information Directorate developed decision support and analytical tools for the Air Operations Centers (AOC), Distributed Common Ground Station (DCGS), and Department of Defense (DoD) intelligence. Under the Distributed Analysis Decision Support System (DADSS) program, the directorate developed tools to rapidly connect to multiple legacy databases and present the data in common timeline, map, graph, and other display types.

The situation alerts capability disseminates alerts to subscribers when predetermined situations begin to unfold. The Web-based capability provides access and display of all connected data sources for viewing via web browser. The directorate transitioned the tools developed under DADSS to the Air Force Web-based Timeline Analysis System (WebTAS) program for transition to AOC, DCGS, and DoD intelligence systems.

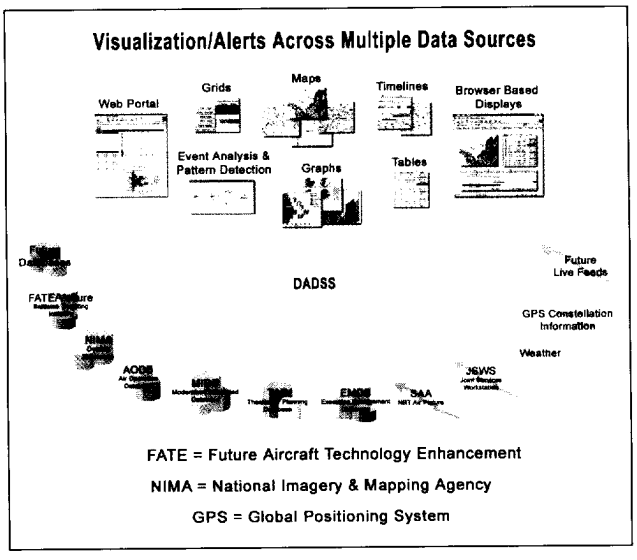
Accomplishment DADSS accesses data from multiple sources and combines the data in common displays for query, visualization, analysis, and decision support to meet AOC, DCGS, and intelligence requirements. DADSS also automatically generates and disseminates situation alerts. The DADSS tools are generic, and trained personnel can site-tailor them for site unique applications. With DADSS enhanced technology, the Air Force (AF) recently deployed WebTAS to Special Operations Command Central Command Forward in the Middle East to support Operation ENDURING FREEDOM.

Background At last year's 8th AF Blue Flag and Roving Sands exercises, the directorate's Fusion Technology Branch, in conjunction with the AF Command and Control Battlelab, successfully demonstrated the flexibility and utility of the DADSS/WebTAS capabilities in an AOC environment. The directorate tailored DADSS/WebTAS to connect to numerous databases and streaming data sources.

Using DADSS/WebTAS, AOC operators queried data from multiple data sources and overlaid the data on DADSS/WebTAS displays. This alleviated the need for operators to go to each separate data source and manually correlate information.

During the exercises, the DADSS/WebTAS rapidly replaced the manual correlation of information by the Combat Search and Rescue operators. Directorate engineers created tailored data views for the Master Air Attack Planning cell, Time Sensitive Target cell, Combat Operations cell, and other cells within the AOC.

Through successful DADSS/WebTAS participation at these exercises, the DADSS/WebTAS software is a leading candidate for Warfighter Rapid Acquisition program funding for transition to operational AOCs in the fiscal year (FY)03/FY04 time frame. DADSS technology is transitioning as part of the directorate's WebTAS program.



The flexibility of the DADSS/WebTAS tools allow it to adapt rapidly to new operational environments. The directorate further proved DADSS' versatility and analytical utility through its adaptation to DoD/Federal Counter Drug Operations (funded by DoD), Law Enforcement (funded by National Institute of Justice), Homeland Defense (funded by Navy), and Intelligence Community programs.

Information Directorate's CyberWolf Transitioned

Payoff The Information Directorate-developed CyberWolf security tool significantly reduces the amount of data a network administrator must analyze. It also provides the administrator with better situational awareness of the security health status of the network.

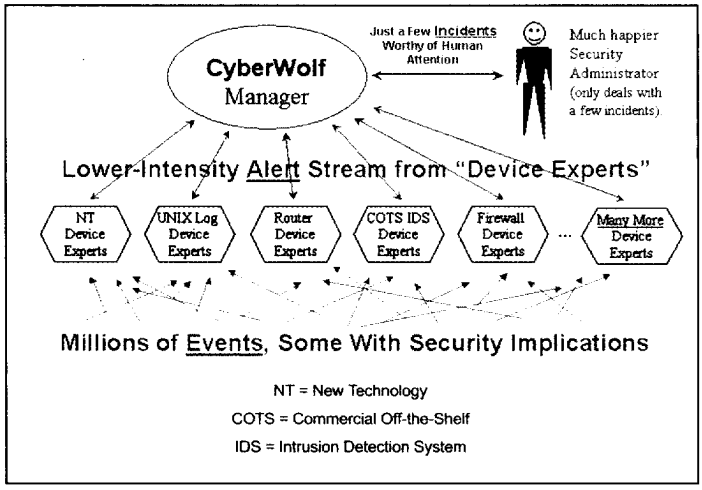
MountainWave, Inc. commercially produced CyberWolf with significant collaboration from the directorate's Defensive Information Warfare Laboratory. This security event management technology provides an automated mechanism to detect security incidents by utilizing intelligent analysis to correlate event streams from intrusion detection sensors and network management systems.

Accomplishment CyberWolf technology automates the detection of security incidents by the intelligent analysis of security events and alerts in real time. Information technology departments struggle with how to manage and respond to the wealth of information generated by the various security applications deployed across the network. The CyberWolf technology addresses those issues by reducing, correlating, and prioritizing security events and alerts, giving enterprises the ability to respond and stop attacks in real time.

The United States Joint Forces Command Joint Battle Center (JBC) evaluated CyberWolf within several operational environments including the Joint User Interoperability Communications Experiment, deployment at the Marine Corps Information Technology Network Operations Center, and Millennium Challenge 2002. Finding it a valuable product, the JBC also introduced the product to the United States Space Command (USSPACECOM), United States Pacific Command, and Air Force Information Warfare Center (AFIWC) for operational evaluation.

Background The directorate, under the Defensive Information Warfare Research program, initiated an effort to assess the integration of intrusion detection and network events associated with cyber warfare and defense. This effort led to a directorate-funded Phase I Small Business Innovation Research (SBIR) effort.

The directorate awarded a Phase II SBIR to exploit the correlation potential of bringing intrusion detection and network management information together for enhanced network situational awareness. The addition of SBIR Phase II enhancement monies created a more robust product for operational evaluation at the Federal Emergency Management Agency, JBC, AFIWC, Air Force Education and Training Command, USSPACECOM, and others.



In July 2002, Symantec Corporation announced the acquisition of MountainWave, Inc. The CyberWolf technology will become an integral component of Symantec's enterprise security solutions, which provide any size organization with the technology, global response, and services necessary to manage its information security.

CyberWolf is a versatile, scaleable, and extensible enterprise security management and computer network defense tool. It employs advanced communications, reasoning, and expert system rule-based correlation and analytical processes.

JASSM Composite Body R2PI Program Saves Millions

Payoff The Joint Air-to-Surface Standoff Missile (JASSM) Composite Body Rapid Response Process Improvement (R2PI) program improved the manufacturing process by reducing the manufacturing risk. This program also reduced the production cycle-time and ultimately resulted in a huge cost savings of more than $19 million.

Accomplishment Under a contract with the Manufacturing Technology (ManTech) Division of the Materials and Manufacturing Directorate, Lockheed Martin Corporation and Fiber Innovations, Inc. (FII) improved the manufacturing process of the JASSM. JASSM is an autonomous, air-to-ground, precision, standoff missile for the US Air Force and Navy designed to destroy high-value, well-defended, fixed and moving targets.

Background Manufacturers use a braided composite process to place fibers in their proper orientation and shape when making most of the surface area and load-bearing structure of each JASSM. Then, manufacturers mold most of these parts using the Vacuum-assisted Resin Transfer Molding, or VaRTM, process.

ManTech approved a plan for Lockheed Martin, in conjunction with FII, to develop the JASSM Composite Missile Body R2PI program to reduce the manufacturing risk of cost and schedule goals for JASSM by improving the manufacturing process. Reducing manufacturing hours, cycle-time, scrap, and rework led to achievement of cost and schedule goals.

Lockheed Martin's technical approach for R2PI eliminated the trimming steps after VaRTM by developing net-shaped preforms for fuselage components. They also improved the net edge molding of the upper and lower composite fuselage by improving the inner mold line dimensional control and optimizing the resin infusion through automated temperature and pressure controls.

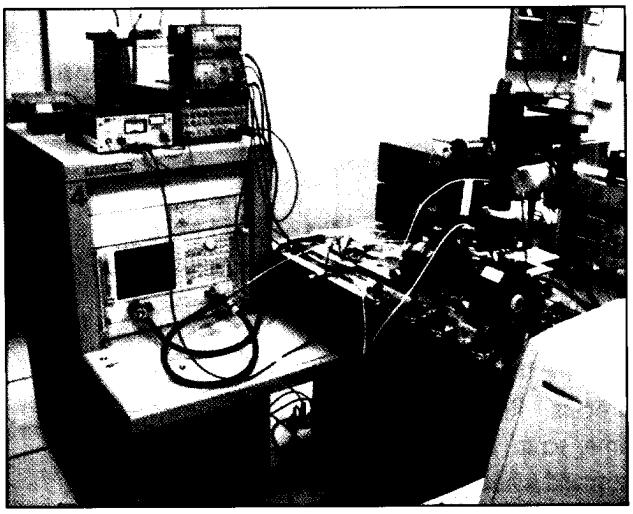
Advancements in Materials Technology Can Simplify and Improve Missile Defense Radar Systems

Payoff Scientists at the Materials and Manufacturing Directorate, Pacific Wave Industries, Inc., and the University of Southern California (USC) demonstrated that they could simplify and improve existing radar to meet several of the national missile defense (NMD) and theater missile defense (TMD) systems' technological challenges by using integrated photonics as opposed to electronics.

This integrated technology approach will result in less costly, more effective missile defense systems designed to protect the United States and its allies. The advancements in materials technology gained through this research will help strengthen national security, while improving the operating capabilities of existing radar systems.

Accomplisment An advanced research effort, supported by scientists from the directorate, Pacific Wave Industries, Inc., and USC, demonstrated that existing radar could dramatically enhance NMD and TMD systems using an integrated technology approach. This technology significantly reduces the size, weight, and complexity of each radar system.

Background Phased array technology offers greater speed and accuracy than conventional radar technologies and is assuming an increasingly significant role in space-based applications. Unfortunately, scientists limit the practical implementation of arrays with thousands of elements due to the complexity of feed structures and active phase-shifting elements.



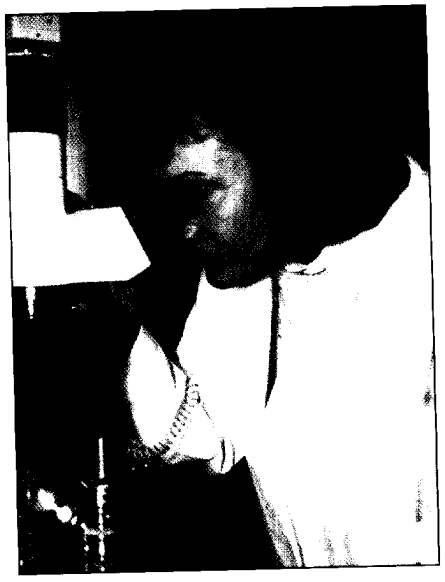
One attractive solution to this problem is the expanded use of integrated photonics. Photonics generates and harnesses light and other forms of radiant energy whose quantum unit is the photon. Applications range from energy generation to detection, communications, and information processing.

Integrated photonics improves phased array beam forming and provides important benefits such as low cost, light weight, and low power consumption. One of the major components of this solution is a photonic radio frequency phase shifter that provides an accurate and easily controllable phase shift.

The advantages of photonics over electronics include light weight, small size, low loss, and immunity to electromagnetic interference—features that enable powerful applications such as true time delay (TTD) and antenna remoting. With support from the directorate and USC, Pacific Wave Industries modified the TTD system using phase delays, thus reducing the size, weight, and complexity of the entire radar system. Pacific Wave Industries developed and tested prototype devices during this research effort to confirm this modification enhances the effectiveness of NMD and TMD systems.

Materials and Manufacturing Directorate Evaluates Effectiveness of Lubrication Grease for Flight Controls and Flight Control Actuators

Payoff Longer intervals between grease lubricant maintenance provides the Air Force with a significant cost savings of $7.2 million over 20 years of aircraft operation, including costs associated with 60,000 hrs worth of unnecessary maintenance and aircraft downtime. By inspecting the operational life of the lubricant, the B-2 Systems Program Office (SPO) safely extended the lubrication maintenance interval for flight controls and flight control actuators from every 600 hrs to every 1,000 hrs—a 67% increase.



Accomplishment The Materials and Manufacturing Directorate's participation in a collaborative effort led to the extension of maintenance intervals for lubricant greases used in the flight controls and flight control actuators of the B-2 aircraft. Representatives from Northrop Grumman; Rexnord Shafer, the bearing manufacturer; and the directorate conducted the analysis and made recommendations that resulted in significant time and cost savings for the Air Force, eliminating unnecessary aircraft downtime.

Background Scientists and engineers from the directorate's Nonstructural Materials Branch, who conduct research and development on nonmetallic, nonstructural materials such as fluids, oils, greases, and solvents, received a request from the B-2 SPO to compare and analyze the effectiveness of the grease lubricant, MIL-PRF-23827, during regular and extended maintenance intervals. MIL-PRF-23827 is diester-base oil grease, supplied by several companies on the military Qualified Product List. This grease minimizes corrosion, wear, and failure in areas where metal components interact with each other.

During the operational life of a lubricant oil, evaporation and exposure to oxygen or water can change the physical and chemical properties of grease, making it less effective. In addition, greases sometimes become contaminated with wear or elastomeric seal debris, which change the consistency of the lubricant and negatively affect the performance of lubricated systems.

Directorate experts examined, compared, and analyzed new, unused grease with samples of used grease, some of which had 600 hrs and some of which had 1,200 hrs of operational life. They analyzed grease samples from four aircraft during maintenance inspections using microscopic and infrared spectroscopic techniques.

Directorate researchers found that while used grease samples had a slightly harder consistency and darker color than new grease, they were not contaminated with wear or seal debris. Researchers concluded the grease was suitable for continued use, had significant life remaining, and a replacement grease or maintenance was not required.

DPSP Program for the JDAM Supports Warfighters and Operation ENDURING FREEDOM

Payoff Six Joint Direct Attack Munition (JDAM) component suppliers dramatically improved productivity by an average increase of 25% and reduced cycle times by 60%. Yet these suppliers maintained cost, quality, and on-time delivery levels as production moved from 300 to 1,500 kits per month.

Under the original production plan, deliveries would accelerate from 300 kits per month in fiscal year 2000 to more than 1,200 kits per month by fiscal year 2003. Thanks in part to the success of the Manufacturing Technology (ManTech) Demand Pull Supplier Pilot (DPSP) program, production is now running at approximately 1,500 kits per month.

Accomplishment The ManTech Division of the Materials and Manufacturing Directorate, under contract with the Boeing Corporation, is supporting the warfighter and Operation ENDURING FREEDOM by increasing production rates for JDAM kits through ManTech's DPSP program. Now in the second year of its 4-year span, DPSP is about the infusion of lean principles into the component manufacturing process for JDAM kits.

JDAM-equipped bombs have seen significant use in Afghanistan during Operation ENDURING FREEDOM. So much so that their production timetable was moved ahead to meet the demand.

Background A JDAM is a guidance tail kit comprised of an inertial navigational system and a Global Positioning System guidance control unit. JDAM converts existing, unguided, 1,000- and 2,000-pound bombs into accurate, adverse weather "smart" bombs. The JDAM, a joint US Air Force and Navy program, demonstrated dramatic precision bombing capability during Operations ALLIED FORCE (Kosovo), DESERT FOX (Iraq), and ENDURING FREEDOM (Afghanistan).

Twenty-two manufacturing enterprises, 11 classified as small to medium enterprises, manufacture all JDAM components. Eight of the 11 are involved in DPSP at this time. Boeing employs a just-in-time production flow system that necessitates consistent, reliable delivery of quality components from all suppliers.

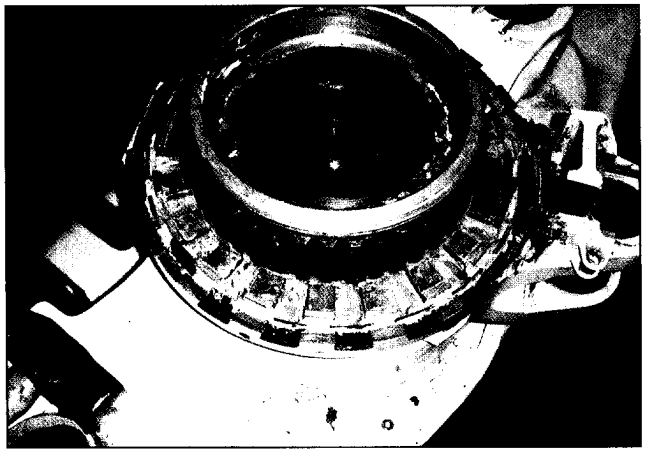
The DPSP program incorporated a variety of lean practices into the supplier's manufacturing facilities, in some cases changing how the company operated. Some of the practices involved cross training of workers on multiple tasks and placing them into U-shaped production cells, standardizing work procedures, and decreasing the time workers spend on the production line for parts acquisition.

Materials and Manufacturing Directorate's Pioneering Lubricant Research Leads to Multi-Purpose Grease that Offers Landing Gear Solution

Payoff Development and testing of a stable, low-cost, rust-inhibiting grease could solve several challenges related to wear, corrosion, and rust in the landing gear assembly of the C-5 aircraft and eliminate costs from associated maintenance or system failures. In addition, the anticipated applications for the new grease are many and will provide significant benefits to manufacturers who meet "military" grease requirements and commercialize a suitable product.

Accomplishment A collaborative research and development effort, spearheaded by the Materials and Manufacturing Directorate, led to the discovery and incorporation of reliable, low-cost replacement grease for cruise missiles. Directorate researchers' continued evaluation and qualification of the moisture-resistant, high-load carrying grease indicate that it may also provide a solution to several wear- and corrosion-related challenges on the C-5 aircraft.

Background In the late 1980s, scientists and engineers from the directorate's Nonstructural Materials Branch began working with various grease companies to find a commercial source of grease to replace a mineral oil clay-thickened product used in cruise missiles. However, no appropriate greases were commercially available.



Military applications use greases to improve and ensure the performance of moving parts. Thus, directorate researchers and contractors from AMOCO designed a unique lubricating grease, ultimately assigned MIL-PRF-32014 military specification, which requires the grease composition to include anti-oxidant, anti-wear, and anti-rust ingredients. AMOCO, under contract, custom made and delivered the lubricant to the Air Force.

Recently, directorate scientists collaborated with representatives at Ogden Air Force Base, Utah, to analyze wear and rust challenges that plague the landing gear of the C-5. Operational requirements expose the aircraft's landing gear assembly to moisture and rain, air, bacterial decontaminants, and other phenomena that encourage corrosion and wear.

After considering several solutions to these challenges, researchers determined that a MIL-PRF-32014 qualifying grease, the same one applied to cruise missile bearings, could offer improved landing gear performance. Because AMOCO was unavailable to continue manufacturing the qualifying grease, Nye Lubricants, a small business that specializes in specialty lubricants, commercialized the MIL-PRF-32014 qualifying polyalphaolefin-base grease called Rheolube 374A.

Directorate researchers conducted rigorous high-humidity and high-speed testing of the grease over long periods of time and in adverse conditions and determined the grease to be a robust, high-performance product. The grease exhibits water washout resistance, high load carrying ability, high-temperature and high-speed performance, and corrosion resistance.

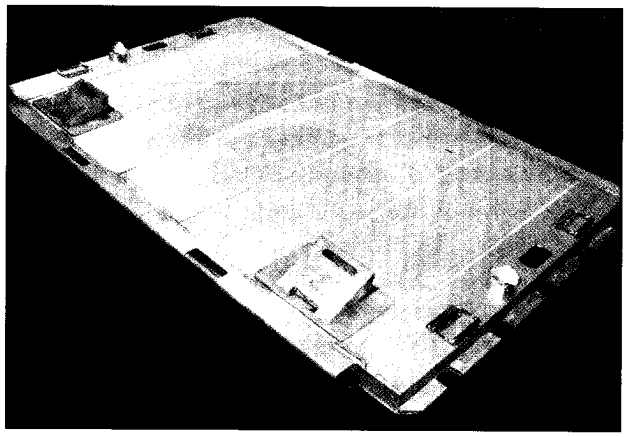
Aluminum Alloy Welding Process Helps Army Streamline Airlift Operations

Payoff A Materials and Manufacturing Directorate-developed aluminum alloy welding process proved critical in manufacturing the United States (US) Army's new cargo interface pallet. The Army expects the new pallet, called a Container Roll-out Platform (CROP) Aircraft Interface Kit (CAIK) to streamline airlift and deployment, improve readiness, and save about $315 million in fabrication cost. Directorate engineers performed much of the work on the new welding process in-house including weld characterization, fracture and fatigue tests and analysis, and corrosion testing and analysis.

The aluminum alloy welding process was critical in manufacturing the CAIK pallet and exemplifies the importance of in-house materials research and development in support of the warfighter. The directorate's contributions to this technology success support AFRL's mission of "leading the discovery, development, and integration of affordable warfighting technologies for our air and space force" and could lead to new ideas and other important applications benefiting military airlift operations.

Accomplishment Directorate engineers supported an innovative research and development effort by the Boeing Company that reduces the time, manpower, and equipment the Army needs to airlift cargo on Air Force transport aircraft. They developed the welding process for the aluminum alloy used to make a special pallet to move the Army's cargo platforms onto C-17, C-5A, and C-130J aircraft; secure them to the floor; and move them off again when the aircraft arrives at its destination.

Background Engineers at the directorate's Metals, Ceramics, and Nondestructive Evaluation Division supported an innovative research and development effort by the Boeing Company that increases the efficiency and reduces the cost of transporting Army cargo on C-17, C-5A, and C-130J aircraft. The researchers assisted in the creation of an aircraft cargo interface pallet, referred to as a CAIK.



The CAIK pallet is a lightweight, sandwich aluminum panel that locks the Army's CROP directly to the cargo floor. The CROP, an important element in the Army's distribution process, carries ammunition, supplies and equipment, light-wheeled vehicles, and track vehicles. However, engineers did not design the CROP specifically for aircraft; consequently, Army soldiers must transfer supplies from the crop to standard aircraft cargo pallets. By using the CAIK and CROP together, the ARMY can move five times the cargo, in two-thirds less time, using the same number of soldiers, and about half the aircraft sorties. The CAIK and CROP combination saves time and equipment and reduces costs.

Directorate engineers developed the welding process for the aluminum alloy under the Metals Affordability Initiative, a consortium between the AFRL, private industry, and academia. The result of their efforts was the friction stir welding (FSW) process used to join the CAIK's longitudinal aluminum extrusions.

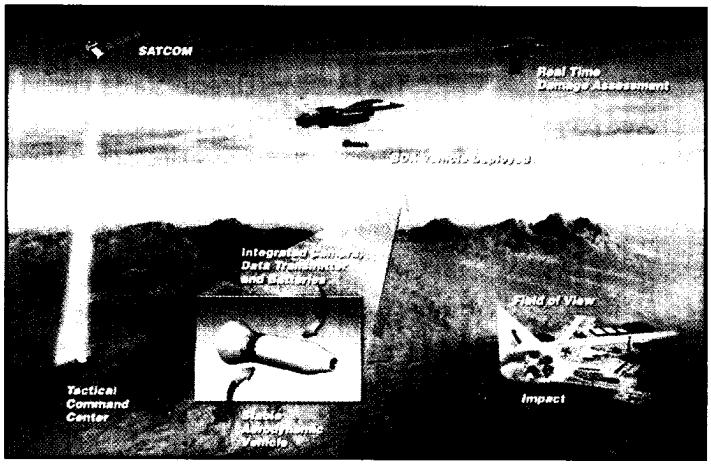
FSW processing enabled the new pallet to become a reality. Of the five fabrication processes initially considered, FSW was the only one that enabled engineers to fabricate the pallet within the program's cost objectives. FSW processing reduced the sandwich assembly cost, including raw materials, extruding, and welding, from 61% to only 19% of the total fabrication cost. Engineers estimate the total cost savings attributed to FSW (for a projected buy of 140,000 CAIKs) at $315 million.

Munition-Deployed Bomb Damage Assessment

Payoff The Munition-Deployed Bomb Damage Assessment (MDBDA) system provides bomb damage assessment (BDA) of targets like no other system. The near real-time imagery collected by the MDBDA sensor allows analysts to immediately determine the effectiveness of a munition by providing real-time BDA information to decision makers. It can save the lives of pilots by avoiding the unnecessary restriking of targets as well as highlighting targets that have not been destroyed during a mission.

Accomplishment The Munitions Directorate at Eglin Air Force Base, Florida, teamed with Northrop Grumman Corporation, Ryan Aeronautical Center, to develop and demonstrate the capabilities of a MDBDA system. The program, a joint government-industry effort, evaluated a system that employs a video camera sensor deployed from and towed behind a falling munition.

The BDA sensor records and transmits video imagery of weapon impact, detonation, and target damage. Such a system can provide near real-time BDA to post-strike mission planners and commanders.



Background Desert Storm revealed that current approaches for collecting BDA information are either ineffective in adverse weather or untimely in their responsiveness to the needs of the air campaign planners. Timely, highly accurate BDA will eliminate targeting redundancy on satisfactorily damaged targets. Such restrikes jeopardize pilots, increase aircraft losses, and waste critical mission sorties.

Collection of BDA information by the striking aircraft itself would subject the pilot to a high risk by requiring him to remain in close proximity to the target area after release of munitions. Similarly, post-strike reconnaissance flights by other aircraft incur the same high risks. To reduce the risk to pilots and aircraft, as well as improve current BDA capabilities, a new system is necessary. A possible solution is the MDBDA system.

After the aircraft releases a munition, the MDBDA spools a camera sensor out from behind the bomb with a specially designed brake system. The brake system consists of a spindle that houses the tether and a specially designed brake that slows the tether payout rate to reduce the load on the tether at the end of the payout.

The camera sensor, housed in an aerodynamically stable body, consists of a high-speed video camera, a video transmitter, and a battery pack. Once the system is fully deployed, the camera sensor transmits real-time video imagery of the munition and its ultimate impact location. The camera captures and transmits several frames of video imagery after weapon impact.

Improved 40 mm Ammunition Fuze for Special Operations Gunships

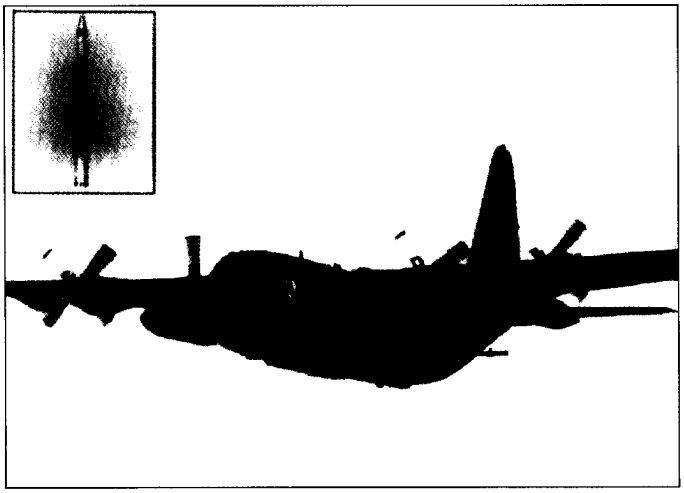
Payoff The Air Force Special Operations Command (AFSOC) will realize an improvement in aircrew safety for its AC-130 gunships with improved 40 mm ammunition fuzes. The modification, made using an adaptation of the existing 30 mm M759 fuze, eliminated the need for a major fuze development program.

Accomplishment The Munitions Directorate developed an improved 40 mm ammunition fuze that is safer, yet provides improved projectile performance at high-impact angles. The fuze design uses an adaptation of the existing 30 mm M759 fuze for use on the AFSOC gunship's 40 mm high-explosive incendiary ammunition.

Background AFSOC briefed directorate personnel on the deficiencies of the MK27 fuzed high-explosive incendiary ammunition. The MK27 fuze, designed during World War II for shipboard defense by the Navy, does not provide adequate aircraft safe separation distance. This deficiency resulted in a 40 mm projectile exploding under the wing of an AC-130 gunship.

After review of the MK27 fuze design, the directorate's Fuzes Branch recommended adapting the 30 mm fuze used in the Army's Apache helicopter gun system for use on the 40 mm ammunition. The standard fuze meets all the safety requirements of the gunship and is compatible with the 40 mm gun.

The new fuze uses a "setback and spin" mechanism, which takes longer to arm giving greater safe separation distance to the round. Directorate personnel designed, manufactured, and tested the fuze adapter in-house with excellent results. The Special Operations Munitions System Program Office awarded a production contract based on the positive results of these tests.

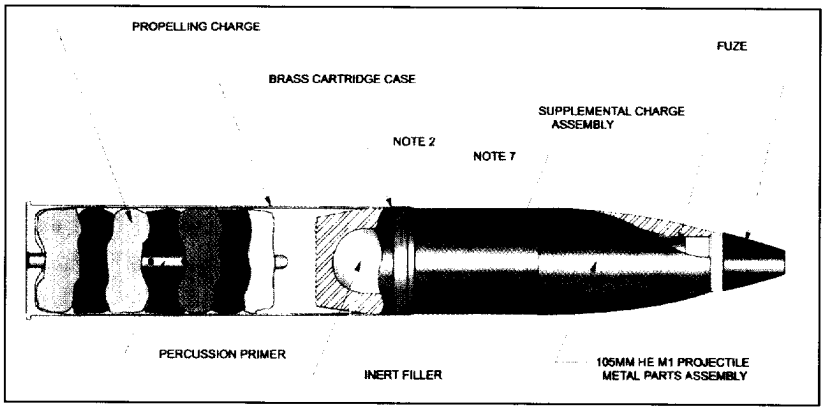


New 105 mm Practice Projectile for Special Operations Gunships

Payoff A new 105 mm practice round saves the Air Force Special Operations Command (AFSOC) approximately $1.2 million per year, increases storage capacity worldwide by 40%, and increases the number of usable AC-130 gunship crew training ranges. Twelve ranges were previously unavailable for training because they prohibited the use of high-explosive projectiles.

Changing to the new practice round was transparent to operators and maintainers alike. There were no software changes to internal and external ballistics because the rounds were identical to service ammunition. The use of inert filler eliminated the possibility of an in-bore malfunction and the need for expensive X-ray inspection, and resulted in AFSOC purchasing 40,000 of the newly designed target practice rounds.

Accomplishment Using excess inert-filled projectiles from a previous 105 mm test, engineers and technicians from the Munitions Directorate's Fuze Experimentation Facility modified, assembled, and ground tested the first 20 prototype 105 mm practice projectiles. Directorate technicians also manufactured and assembled the projectiles used in flight testing at Eglin AFB, Florida.



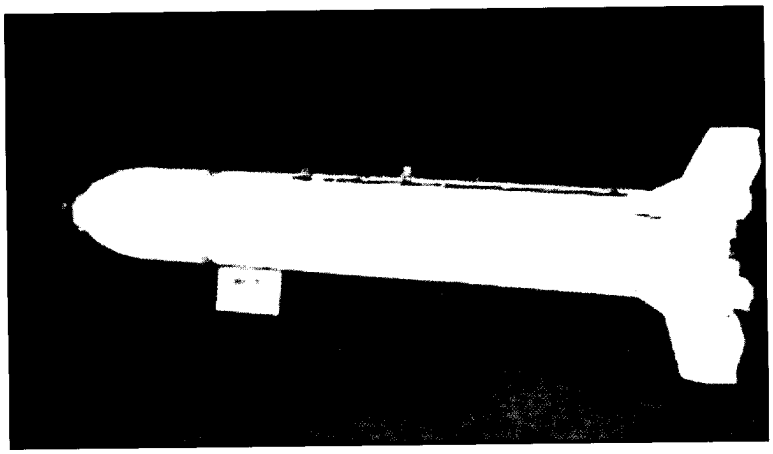
Background AFSOC notified the directorate of the need for a new projectile to replace the projectile used in training AC-130 gunship crews. Normally, AC-130 crews use a 105 mm high-explosive cartridge known as the HE M1.

Crews fire regularly to exercise the firing proficiency capabilities of the aircraft and to train crew members. AFSOC AC-130 gunship aircrews fire about 18,000 rounds of 105 mm ammunition every year at a cost of approximately $7 million. The main reason for requesting a new projectile was the depleting stockpiles and cost of the high-explosive projectile used for training.

New Leaflet Bomb for High-Speed Deployment

Payoff The Munitions Directorate delivered a critically needed, high-performance leaflet bomb to the warfighter. Directorate engineers modified MK-20 (Rockeye) dispensers scheduled for destruction in order to meet the requirement for an advanced leaflet bomb in minimum time and with minimal developmental costs, ultimately resulting in overall cost savings to the government.

Accomplishment Within 3 weeks of notification, directorate personnel from the Fuzes Branch obtained a Rockeye dispenser from the 40th Test Squadron at Eglin Air Force Base, Florida, removed the bomblets, and replaced them with leaflet rolls. Directorate engineers then successfully flight tested the newly designed leaflet bomb at Eglin's Range B-70. The leaflet bomb properly dispersed the leaflets within user requirements.

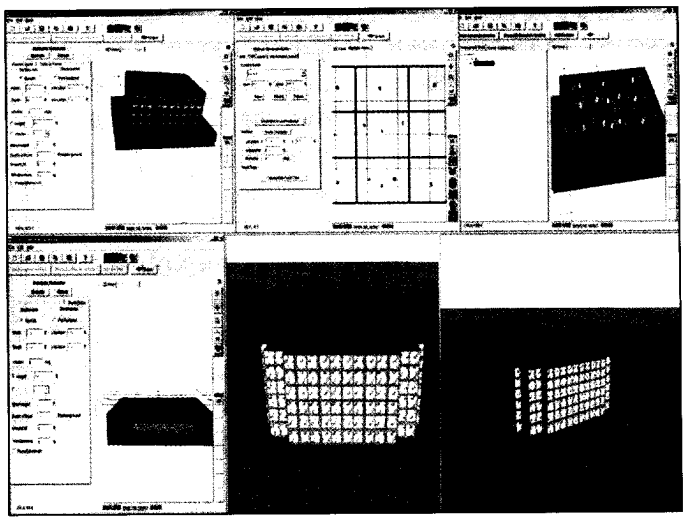


Background The Air Combat Command briefed Air Armament Center personnel on the deficiencies of the M129 leaflet bomb for use in Afghanistan. The Department of Defense designed the M129 during World War II for dispensing leaflets; however, it did not meet the performance requirements for use on modern high-speed aircraft. The Air Force needed a quick turnaround on a low-cost, new leaflet bomb.

Smart Target Model Generator

Payoff The Smart Target Model Generator (STMG) allows Munitions Directorate engineers to rapidly generate target models for weapon effectiveness simulations for conceptual and inventory munitions analysis. The STMG reduces time and increases fidelity of ground-fixed target models generated for conventional weapon effectiveness simulations.

Accomplishment The directorate's Lethality and Vulnerability Branch, through a Phase II Small Business Innovation Research (SBIR) program contract with Applied Research Associates, developed three-dimensional (3-D) structural modeling software that rapidly generates realistic 3-D building models of military and industrial targets. The tool also allows users to drag and drop critical components into target models and evaluate the effects of conventional weapons against critical components inside military targets.



This new software tool reduces modeling and weapon assessment time for engineers, simulating the effectiveness of conceptual and inventory weapons against ground-fixed military and industrial targets. Directorate engineers used this 3-D modeling tool to model the Social Hall Building in support of the 2002 Winter Olympics protective security planning efforts by various government agencies.

Background The Lethality and Vulnerability Branch provides expeditious weapon effectiveness analyses of weapons concepts against a variety of building targets. Existing target modeling tools do not provide target model generation capabilities adequate for quick turnaround weapon effectiveness assessments.

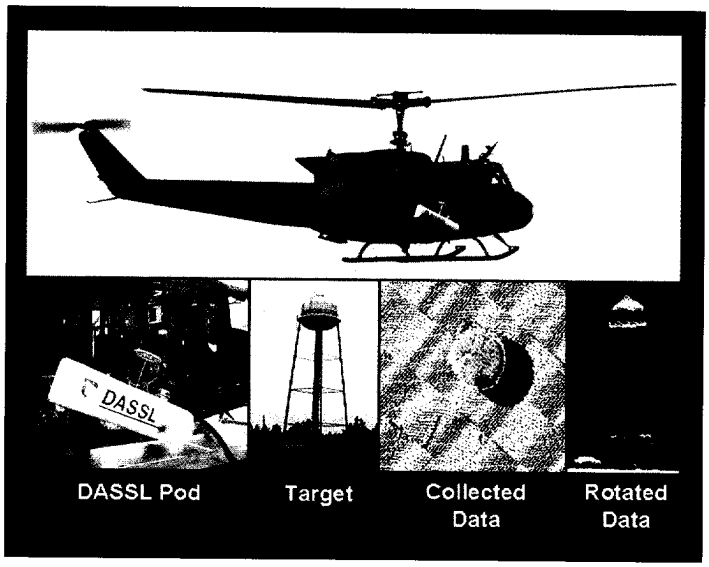
The Department of Defense needed a tool to rapidly produce models of different types of buildings. In response to this need, directorate engineers, under a SBIR Phase II contract, developed a tool that allows users to rapidly generate 3-D models of target scenes.

These models provide the target data needed to support the various algorithms in the weapon assessment tools. Directorate engineers are using the STMG to support various government agencies in protective and security planning for civil defense security programs.

AFRL Develops DASSLing Aimpoint Selection

Payoff The Munitions Directorate's Demonstration of Advanced Solid State LADAR (DASSL) program, a joint effort with the Navy, developed a family of laser radar (LADAR) seekers that identifies targets and provides aimpoint accuracies exceeding those of current guided weapons. This increase in accuracy allows the warfighter to attack a greater variety of targets with smaller warheads, reducing the potential for collateral damage.

Accomplishment In a joint effort with the Naval Air Warfare Center (NAWC) and Raytheon, directorate scientists developed seeker designs to address seven scenarios containing mobile, relocatable, and high-value fixed targets. These designs satisfied the requirements for both the Air Force miniature munitions and the Navy cruise missile.



The program generated technological advancement of many LADAR components having increased capability, smaller size, lower cost, and higher reliability, while expanding the LADAR technology industrial base. By using these improved common components and subsystems, the Air Force could realize savings of up to 70% of the seeker's cost.

As the Project Reliance lead for munition LADAR seekers, the directorate provided expertise in laser components, systems, and algorithm development, while NAWC provided additional laser experience, algorithm development, and seeker design and construction. Both services, working to achieve common design goals, developed more mature systems to better meet all program goals.

Directorate personnel developed target models and seeker algorithms that detect, classify, and track high-value, fixed targets using the LADAR imagery. They incorporated these algorithms in the DASSL seeker and demonstrated closed-loop, real-time acquisition and tracking during captive flight tests.

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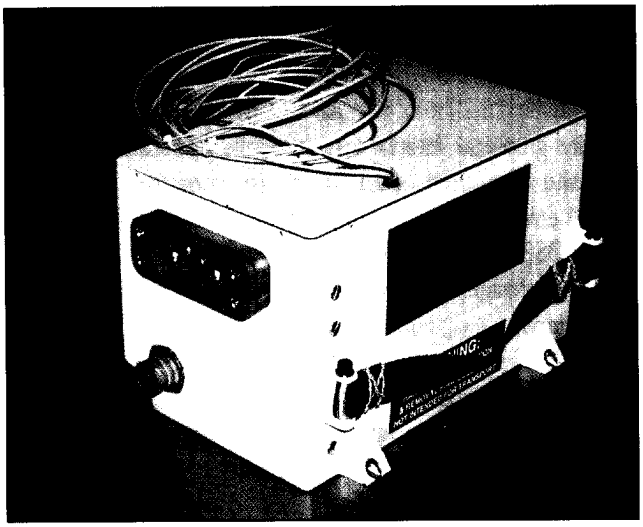
First-Ever Lithium-Ion Main Aircraft Battery Ready for the B-2 Spirit

Payoff The Propulsion Directorate, along with industry partners, developed the first-ever main aircraft battery using advanced lithium-ion technology for the B-2 Spirit. The lithium-ion battery (shown below) boasts the advantage of five times the energy output with the same weight of the currently used nickel-cadmium (Ni-Cd) battery in a form, fit, and function replacement. This battery has an estimated useful life of 2-3 years and is virtually maintenance free.

Accomplishment The 36 lb lithium-ion battery will replace the existing vented Ni-Cd battery. The directorate designed the new battery to fit dimensionally into the existing B-2 battery case and function with the existing charger system to avoid a costly charger modification.

Implementing the new technology provides five times the existing battery capacity and exceeds the performance requirements of the upgraded B-2 aircraft. An equivalent sealed Ni-Cd battery would weigh approximately 108 lbs and require structural modification to the aircraft and battery compartment.



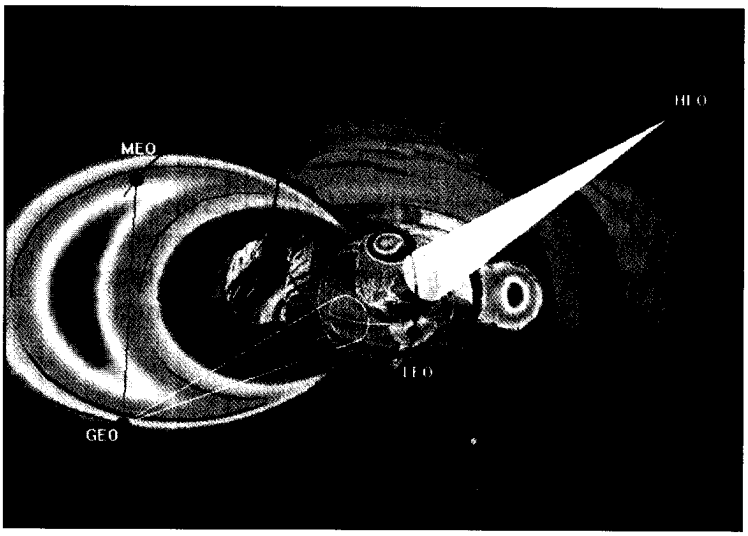
Background The directorate, along with industry partners, successfully developed the lithium-ion technology and tested the battery for the B-2 Spirit. Directorate researchers partnered with Yardney, Inc. to make this advanced battery capability available for use.

The program's goal was to create a battery of the same size and weight that generates greater capacity at a lower temperature. The battery has undergone low-temperature, high-temperature, and life-cycle tests with excellent battery performance. It supplies the required capacity at low temperatures and higher than required capacity at normal temperatures.

AF-GEOSPACE: Environment Tools for Satellite Operators and Designers

Payoff The Space Vehicles Directorate's Space Weather Center of Excellence developed the new AF-GEOSPACE software suite of near-earth space environment models in use by Department of Defense (DoD) operational, planning, and acquisition organizations. AF-GEOSPACE provides three-dimensional space environment specification and selected forecast capabilities vital to the DoD space operations, communication, navigation, and surveillance missions.

Accomplishment AF-GEOSPACE is a user-friendly graphical interface to models, applications, and the real-time data used to monitor the space environment. DoD organizations can use AF-GEOSPACE to make critical decisions in the planning, design, operations, and post-event stages of missions.



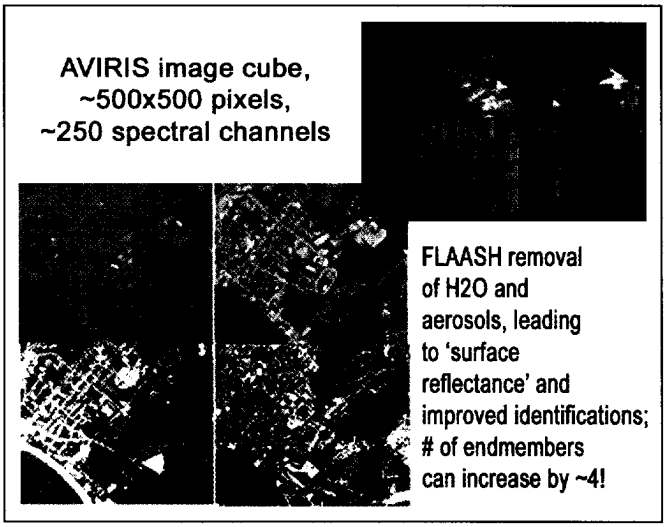
Hazardous environments addressed include the radiation belts and solar particles responsible for spacecraft degradation, global electron density variations affecting high-frequency communication and geolocation, and ionospheric scintillation regions responsible for satellite communications and Global Positioning System navigation signal outages. Previously available only for Unix operating systems, this Windows® version facilitated the rapid transition of the directorate's technology to well over 100 users in DoD operations, training and simulation facilities, the spacecraft design industry, and research and educational institutions worldwide since its release in May 2002.

Background AF-GEOSPACE Version 2.0 for Windows is the latest product in the spiral software development of the directorate's Spacecraft Environment Interactions Modeling Advanced Technology Demonstration. AF-GEOSPACE provides access to the practical results of many years of space environment research performed by the directorate and others in the space weather community. It also serves as a platform for the development and validation of future operational products.

25 Years of Progress in Atmospheric Transmission

Payoff The Department of Defense (DoD) Atmospheric Transmission Conference attracts important members of the atmospheric electro-optical communities from within the DoD, such as the Space Vehicles Directorate; other government agencies; universities; and the international arena including the North Atlantic Treaty Organization partners. The data exchange and knowledge base helped solve important or difficult operational problems.

Accomplishment Over its 25-year history, the interaction at the DoD Atmospheric Transmission Conference helped solve important or difficult operational problems. Among these are development and validation of Air Force models and codes that equip DoD agencies with the ability to model, simulate, and compensate/correct data related to evolving surveillance systems for background atmospheric effects. Some of the directorate's codes enabled by the conference's 25-year history include MODTRAN, SAMM, SHARC, AURIC, MOSART, PLEXUS, AARC, FASCODE (all related to simulation capabilities), and FLAASH (plus its derivatives), which infer surface properties from measured radiances.

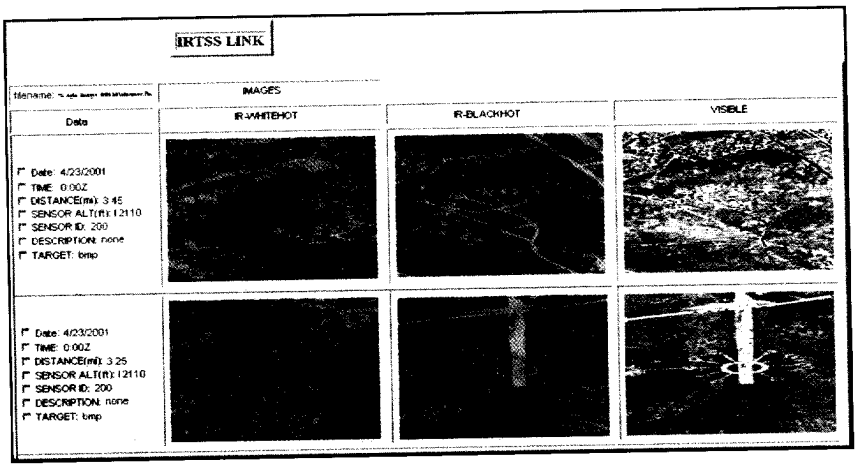


Background New technologies require the evolution of physics-based models that involve detailed knowledge and understanding of atmospheric absorption, scattering, structure, local thermodynamic equilibrium (LTE) and non-LTE, molecular spectroscopy, atmospheric composition, surface characterization, hyperspectral imaging, laser propagation, polarization theory, and many other areas of expertise.

Infrared Target-Scene Simulation Software

Payoff Infrared Target-Scene Simulation Software (IRTSS) simulates target-area scenes as seen on the cockpit display for infrared (IR) weapon systems. These scenes include time-of-day and weather effects for any attack altitude and heading.

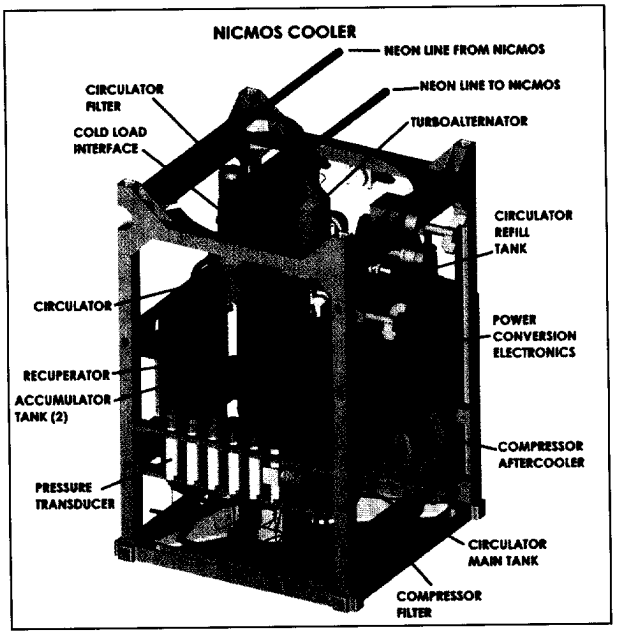
Accomplishment Space Vehicles Directorate personnel transitioned IRTSS to support Red Flag exercises at Nellis Air Force Base, Nevada. Pilot use of IRTSS during mission rehearsal improves situational awareness and optimizes attack effectiveness, while reducing critical pilot "heads-down time."



Background IRTSS generates visualizations by running physics/engineering-based (IR thermal, atmospheric, and sensor) models over a user-specified geographic area populated with user-specified target types and locations, based on forecast weather data input. IRTSS comes pre-packaged with geographic data sets and targets. The software derives target representations from knowledge of target geometry and material composition.

Near-Infrared Camera and Multi-Object Spectrometer Cryocooler

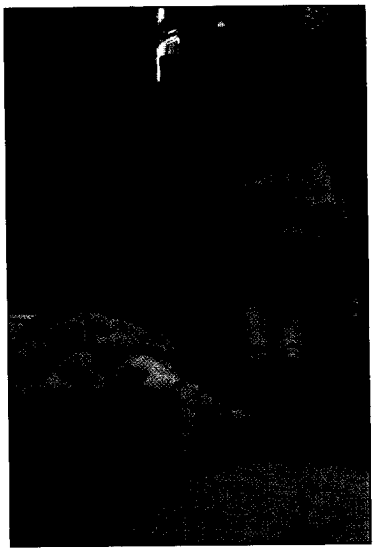
Payoff The Space Vehicles Directorate's Space Cryogenic Technology Team contributed to the development and demonstration of critical cryocooler technology that helped revive the Near-Infrared Camera and Multi-Object Spectrometer (NICMOS) instrument that failed on the Hubble Space Telescope.



Accomplishment The team's expertise, groundbreaking technology development, essential Air Force hardware, and laboratory characterization of prototype hardware for this cooler technology to the National Aeronautics and Space Administration (NASA) helped revive the NICMOS infrared instrument. The effort culminated in March 2002 with a space walk and installation by NASA astronauts on the Hubble Space Telescope.

Background The directorate participated in the development of a turbo reverse Brayton cryocooler, which helped NASA return the NICMOS camera to its optimum operating temperature. Directorate scientists expect the new cooler to nearly double the NICMOS' operational lifetime.

The directorate's Space Cryogenic Technology Team was instrumental in the development of the fundamental technology for reverse Brayton cryocoolers. The directorate coordinated the cryocoolers development through a series of Small Business Innovation Research programs and Air Force- and Missile Defense Agency-sponsored cryocooler development programs.



Emerging Technologies

Continued on next page

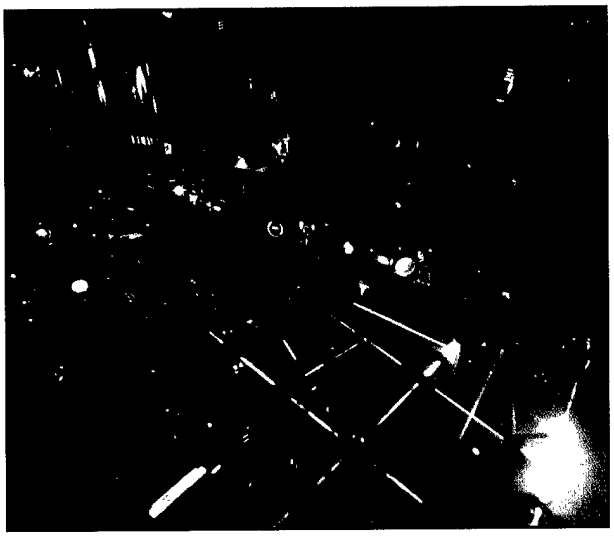
Emerging Technologies

Freezing Light in its Tracks

Stopping light and releasing it without losing any of its original characteristics could be the breakthrough for a new generation of computers called quantum computers. "Quantum" refers to discrete changes in the energy or phase of atomic levels. These computers may solve problems completely inaccessible to today's computers.

Another field to benefit from this breakthrough is nonlinear optics with applications from telecommunications to imaging, which could be useful in designing ultra-sensitive optical switches. Other practical uses include new ways to communicate solely by light and coding methods to protect both military and personal information.

In 2000, the Air Force Office of Scientific Research (AFOSR) began sponsoring Dr. Lene Hau's research. By using a cluster of cooled atoms, Dr. Hau and her team of researchers stopped light in its tracks. A second laser beam converted the frozen pulse back into a moving light pulse, but significantly with all of its original properties. This allows the researchers to control a light pulse by capturing and storing it, thus enabling them to release it at will. She and her colleagues "...believe that this system could be used for quantum information transfer...and with use of photon-to-atom interactions, quantum information processing may be possible during the storage time."



Continuing under AFOSR sponsorship, Dr. Hau and her group are currently continuing their research into optical information storage in an atomic medium using halted light pulses.

Sponsored by AFOSR, Dr. Hau, a Gordon McKay Professor of Applied Physics and professor of physics at Harvard University in Cambridge, Massachusetts, first slowed a light pulse down to a leisurely 38 miles per hour and eventually stopped it completely. Researchers accomplished this by creating a small cigar-shaped cloud of sodium atoms trapped in a magnetic field and cooled to a temperature within a millionth to a billionth of a degree of -459.7°F, referred to as absolute zero. Absolute zero is the temperature at which atoms have the lowest amount of energy.

Next researchers illuminated the cloud with a carefully tuned laser beam that altered the optical properties and then sent another light pulse into the cloud. This combination of laser beams, magnetic fields, and radio waves cooled the sodium atoms.

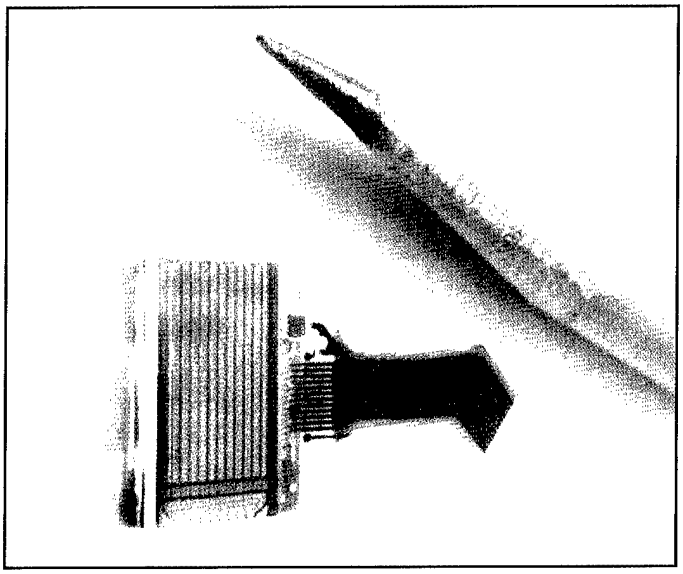
Using a similar technique to completely stop the pulses, a laser beam can convert the frozen pulse back into a moving light pulse, but significantly with all of its original properties. This allows researchers to control a light pulse by capturing and storing it, thus enabling them to release it at will.

New Instrumentation Allows Researchers to Probe Microscale Fluid Motion

Professor Carl Meinhart, at the University of California Santa Barbara (UCSB), recently developed a new instrument to measure the motion of fluid inside microfluidic devices at thousands of points simultaneously. The device, a micron-resolution Particle Image Velocimetry (micro-PIV) instrument, will enable scientists to better understand the basic physics of fluid motion at the microscale.

The Air Force Office of Scientific Research and the Defense Advanced Research Projects Agency jointly funded this research under the MEMS [microelectromechanical systems] for Flow Control program. The micro-PIV device will lead to improvements in the design of micro-fluidic devices.

Micro-PIV works by making measurements of the displacement of small fluorescent particles in the flow. Researchers can determine the fluid velocities in the device by tracking the displacement of these particles during a short time interval using two pulses of a laser beam. Professor Meinhart required innovations in the imaging system, data processing, and seed particles to develop the micro-PIV system.



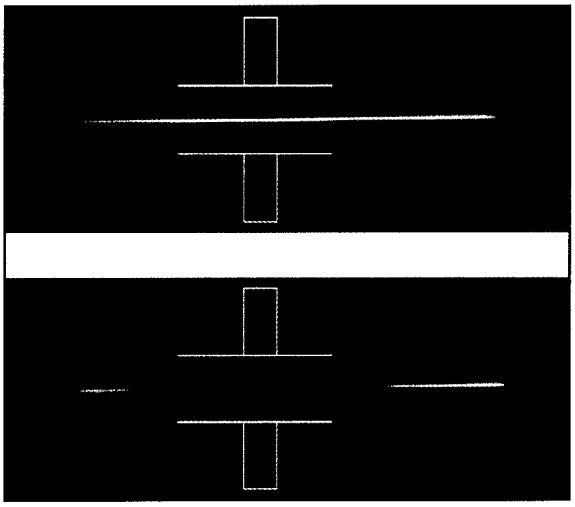
Recent market surveys indicate by the year 2003, worldwide sales for microfluidic devices will be $3.8 billion or about 40% of the total MEMS market. Industry experts expect worldwide sales to grow at an annual rate of 25-35%. The majority of current sales involve inkjet printer heads, although researchers are developing new applications in a variety of fields.

In printer head applications, researchers at UCSB used micro-PIV to measure liquid flow through a micro-nozzle. Traditionally, manufacturers designed inkjets based on trial and error, empirical models, and computer simulations of the fluid motion. Micro-PIV measurements provided the first detailed velocity measurements inside an inkjet printer head.

Biotechnology researchers can also use micro-PIV to investigate the interaction between microscale fluid motion and cells. Previous research reported that shear stress on endothelial cell walls cause them to change their shape. Researchers combined micro-PIV with Atomic Force Microscopy to simultaneously measure the fluid motion and cellular shape around cultured endothelial cells. They are currently developing microfluidic devices for use in biomedical diagnostics, biotechnology sensors, and for a variety of aerospace applications including sensors, thrusters, and actuator devices for flow control.

Discovery of a New Mechanism Controlling Persistent Radiation from Hypersonic Vehicles

Professor William Rich and a group of scientists at the Ohio State University, supported by the Aerospace and Materials Sciences Directorate of the Air Force Office of Scientific Research, recently discovered a mechanism that may suppress radiation emitted by hypervelocity aerospace vehicles (vehicles traveling at speeds several times greater than the speed of sound). Hypervelocity aerospace vehicles, such as ballistic missiles, emit ultraviolet-visible radiation trails that persist for long distances behind the vehicle during parts of their flight trajectory.



Professor Rich's group observed that various modes of motion of energetic molecules in the flow field create a persistant ultraviolet (UV) radiation trail.

Various forms of radiation, at UV, visible, and infrared wavelengths, come from different molecular modes of motion. When some electronically excited molecules lose energy, they emit UV-visible radiation. However, some electronic states and all the vibrationally excited states do not radiate strongly at UV-visible wavelengths. Scientists refer to these states as "dark states."

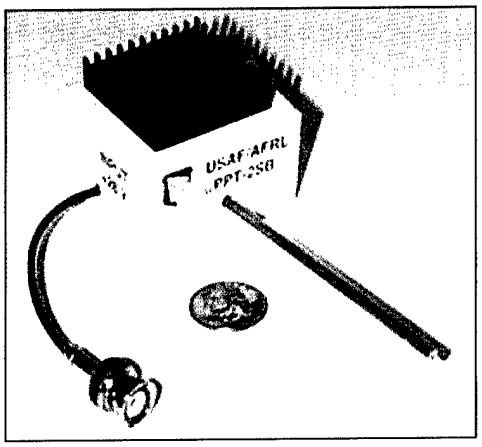
In experiments conducted at the Ohio State University, Professor Rich's team developed strong evidence to show that some of the "dark states" strongly affect the UV-visible radiation through an indirect but critical mechanism. The group concluded that the critical mechanism controlling this transfer came from the small concentrations of free electrons that are typically present in these hypersonic flow fields. Hence, if one removes the electrons from the plume, either by means of adding additives or other physical controls, the UV signature can be suppressed.

Micro-Pulsed Plasma Thrusters to Fly on Air Force Satellites

Impact Dr. Gregory Spanjers, a member of AFRL's electric propulsion group, recently invented a class of miniaturized electric propulsion thrusters called the micro-pulsed plasma thruster (MicroPPT). This thruster is capable of providing primary thrust for on-orbit operations as well as thrust required to change the satellite's orbit. Supported by the Air Force Office of Scientific Research's Aerospace and Materials Sciences Directorate, Dr. Spanjer's invention will enable future microsatellites to perform surveillance, on-orbit servicing, inspection, and space control.

Accomplishment Microsatellites are low-cost satellites weighing between 10-100 kilograms. In the future, scientists expect fleets of micro-satellites, weighing about 25 kilograms and operating independently or in formation, to perform numerous space missions.

Dr. Spanjer's MicroPPT device produces thrust by using electromagnets to accelerate ionized propellant particles, which are ablated from the face or surface of the solid Teflon propellant. The solid propellant reduces the satellite weight and size by eliminating the propellant feed system. The use of electromagnetic acceleration to create thrust leads to a higher specific impulse (or thrust per unit propellant weight) for the thruster as compared to chemical propulsion systems.



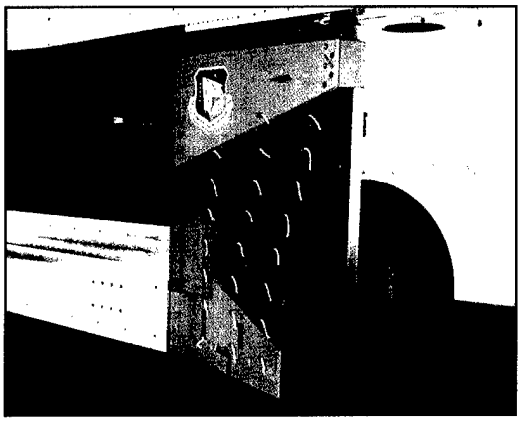
Background The MicroPPT evolved from a radical reengineering of the pulsed plasma thruster originally developed in the 1970s. By removing all nonessential hardware and simplifying the electronics, the MicroPPT represents improvements that are about 50 times greater than capabilities of current, state-of-the-art designs. The finished product weighs only 660 grams, while some experimental lab models weigh even less—well under 100 grams.

Continuous Moldline Technology

Continuous Moldline Technology (CMT) offers substantial performance payoffs for numerous applications. Variable geometry fuel cells and inlets are two notable examples where CMT can reduce aerodynamic drag throughout a mission profile and, therefore, extend the range of the vehicle.

In addition, application of CMT to bridge the gap between movable control surfaces and fixed wing structure improves the aerodynamic effectiveness of the control surface and can reduce the noise generated by the unsealed gap. Eliminating the moldline discontinuities around the deflected surface also eliminates effectiveness losses associated with aerodynamic gap spillage and reduces flow separation.

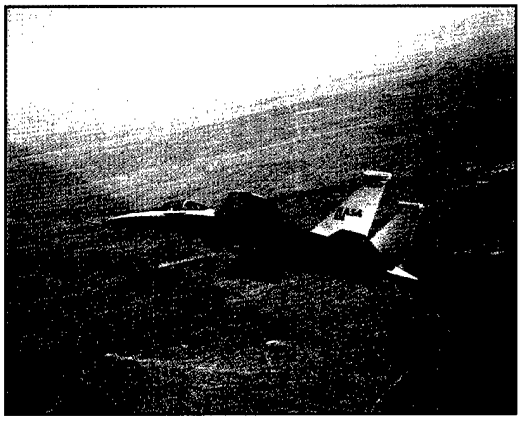
Air Vehicles Directorate engineers recently conducted a flight demonstration of CMT—an innovative structural concept that uses highly flexible materials to enable in-flight modification of airframe geometry. CMT consists of an elastomeric matrix, reinforced with stiffening rods that are able to slide within the matrix to achieve very high deformation.



In order to validate the flight worthiness of this flexible structure, the team modified the trailing edge of the National Aeronautics and Space Administration's (NASA's) F-15B Flight Test Fixture to subject a CMT structure to the full operational envelope of the test aircraft. The flights covered the operational envelope of the test aircraft, testing the CMT structure up to Mach 1.7, dynamic pressures up to 990 psf, and altitudes from 5,000 to 40,000 ft.

The team obtained aerodynamic pressures and CMT structural response data for deflections of the CMT surface up to 30°. Preliminary inspections of the CMT structure reveal no signs of wear or damage after the 5 hours of flight tests.

Adaptive airframe structures would enable in-flight modification of vehicle geometry (morphing) and allow for air vehicle designs that can perform more effectively over a wide range of flight conditions and for multiple missions. While it is easy to see how an adaptive structure can improve aerodynamic performance, the key to realizing these aerodynamic benefits on an air vehicle is to minimize any penalties associated with the adaptive structure versus a conventional structure. Weight, cost, and actuation power requirements are all potential penalties that could limit the effectiveness of CMT applications.



While the basic CMT structural design concept is generic to various applications, directorate researchers chose the continuous control surface application as the initial focus due to availability of experimental test assets. Prior to the flight demonstration, the team conducted a wind tunnel demonstration of a continuous control surface on a scaled fighter aircraft model in a low-speed tunnel at NASA Ames Research Center.

A continuous control surface uses CMT along the hinge line and as a transition between fixed structure and the actuated surface. The team performed an analysis of test environments, cost, and data collection possibilities and identified the NASA F-15B Flight Test Fixture as the best test bed for continuing the development of CMT.

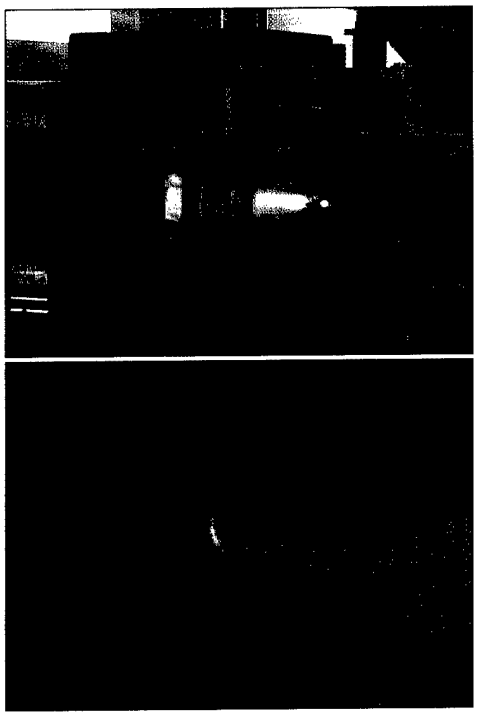
Mach 5 Plasma Flow Channel Development

Exploiting plasmas for direct electromagnetic energy addition to air could allow flow control with no moving parts. Magneto hydrodynamic (MHD) technology, for example, could do away with the mechanical complexity of variable-geometry hypersonic engine inlets, reducing vehicle weight as much as 25%. MHD has the potential to control aero heating to aerospace vehicles.

National Aeronautics and Space Administration studies show that increasing the heat capacity of a reusable launch vehicle by 10% could increase range by 10%. The Air Vehicles Directorate's Plasma Flow Channel will permit quicker testing of concepts like these through faster cycle times and lower cost for experimentation.

Based on experience with the Mach 6 Wind Tunnel Facility, the directorate's Aeronautical Configuration Branch Experimental Plasma Team drew up specifications for, and developed, a new, smaller scale, all-plastic wind tunnel dedicated to plasma research. Less than a year elapsed from conception to first plasma generation. This facility shows superb flow quality over a large test volume.

The Plasma Flow Channel bridges a gap in plasma flow testing between bench-scale devices, with test volumes of only a few cubic centimeters, and range-tests, in which engineers fire projectiles through standing plasma. The new plasma flow channel has a test section of almost 2,000 cubic centimeters and is essentially continuous-running, requiring only one engineer to operate rather than the three required to operate the Mach 6 facility.



Interest in plasma flow control developed in the mid-1990s amid reports of Russian experiments in the field. Computation of these flows combines the physics of reacting gas flows with Maxwell's equations for electromagnetics. These computations require validation.

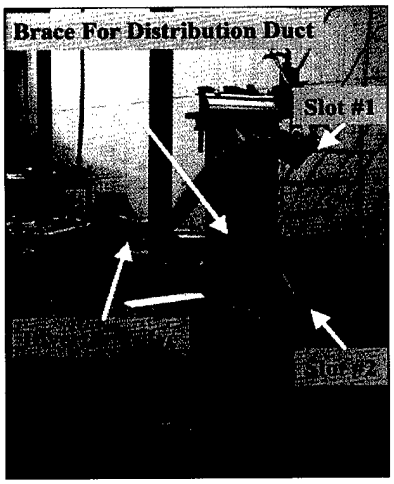
The directorate urgently needed experimental verification, but experiments required extensive modifications to existing facilities. The first attempts at wind tunnel experiments in hypersonic plasma flow control in the directorate took place in the Mach 6 High-Reynolds Facility.

Researchers encountered severe difficulties in trying to generate plasmas in this facility, especially in unintentional ground paths through the metal tunnel walls. Operation of the facility required a three-man crew, resulting in long cycle times and high costs for experimentation. The new all-plastic tunnel requires only one-man crew, and cycle times and costs have been reduced by approximately 50%.

ACE Control Program Completes Cold Flow Test

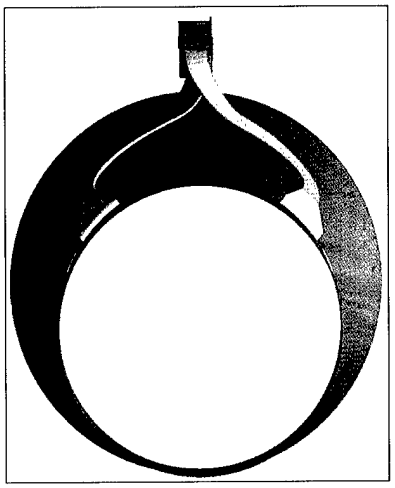
Accomplishment of the Cold Flow Test was a significant risk reduction step toward the ultimate goal of demonstrating the Active Core Exhaust (ACE) system on a C-17 aircraft by the end of fiscal year 2002. Air Vehicles Directorate engineers expect ACE to eliminate $6.5M in core thrust reverser maintenance costs over a projected 30-year fleet life of C-17 aircraft. Additionally, integration of ACE will reduce the cost of each new aircraft built by approximately $1.2M and reduce the weight of every aircraft built or retrofitted by approximately 1,200 lbs.

Engineers at the Georgia Tech Research Institute laboratory facilities in Atlanta, Georgia, recently completed a critical test phase of a significantly improved pulse distribution system for the ACE Control program. This Cold Flow Test involved piping unheated compressed air through half of a redesigned, full-scale ACE distribution system and measuring the magnitude and quality of air pulses emanating from injection slots.



Test results showed nearly a fourfold improvement in pulse strength as compared to the baseline ACE system. Data analyses indicated that this level of performance should easily achieve the program objective of inducing a 50% reduction in the temperature of the engine core exhaust plume at the idle reverse thrust setting.

The ACE Control System, a fully integrated, non-intrusive pulsed injection system, destabilizes the engine core exhaust plume, resulting in enhanced mixing of the plume with the surrounding air. Injecting a small amount of compressor bleed air perpendicular to the core exhaust flow at the core nozzle exit induces the destabilization, or flapping, of the plume.



The ACE system routes the bleed air in an oscillatory manner to alternating sides of the core nozzle, resulting in a decrease of the exhaust plume temperature. The reduced plume temperature permits removal of the core thrust reverser (CTR) from the F117-PW-100 engine on the C-17 aircraft.

The primary function of the CTR is to maintain human effectiveness temperature requirements for loadmasters during engine-running on/off (ERO)-load operations. In great contrast to the CTR, ACE is a fluidic system with no moving parts that maintains a tolerable ERO environment for the loadmaster.

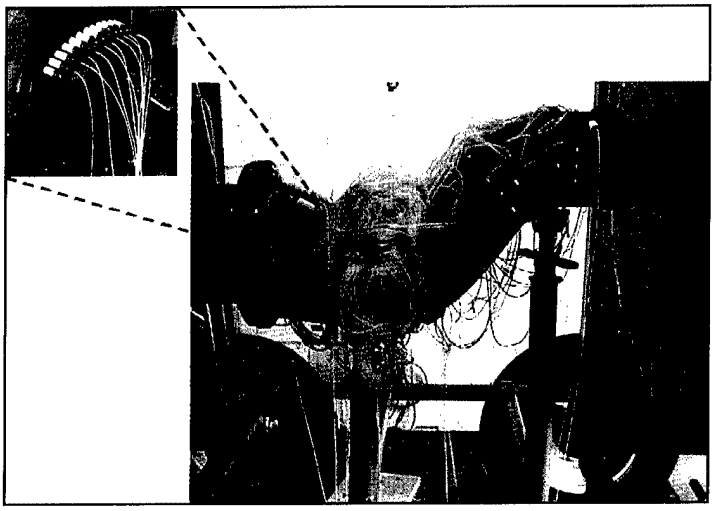
The current and final phase of the ACE Control program, referred to as Phase IIA, is an optimization effort of the ACE pulse generation and distribution system. Based on the results of Phase I testing and Phase IIA component experimentation, engineers made design changes to enhance mixing effectiveness and improve the performance of the pulse distribution system.

Directorate engineers fabricated and shipped proposed configurations to a subcontractor for laboratory testing. Phase IIA will culminate in a full-scale Hot Flow Test of the improved ACE system on a simulated C-17 nozzle.

Air Vehicles Directorate Demonstrates a Compact, Highly Offset Serpentine Inlet Duct

Realistic flight conditions, such as aircraft maneuvers, constantly change the degree to which serpentine inlets distort the airflow, causing fluctuations in aircraft performance. A feedback control system is therefore necessary to deliver appropriate pressure distortion control during any given flight condition to maintain aircraft performance. Using this technology will allow for smaller, lighter, more cost-efficient unmanned air vehicles (UAVs) with consistent performance levels as the controller adjusts and corrects for air flow distortions less than a second after receiving feedback.

The Air Vehicles Directorate, in cooperation with Techsburg, Inc., demonstrated, for the first time anywhere, closed loop control of pressure distortion in a compact, highly offset serpentine inlet duct. The directorate and Techsburg, Inc. performed the demonstration under the US Air Force Small Business Innovation Research program, using flow control techniques developed with Lockheed Martin Aeronautics Company and the National Aeronautics and Space Administration's Glenn Research Center.



Microphones measuring the amplitudes of the pressure fluctuations at the exit plane of the inlet served as the non-intrusive feedback sensors for this study. Directorate engineers hypothesized that microphones near the distorted flow would record higher amplitudes of pressure fluctuations compared to microphones near the undistorted flow.

The engineers discovered that the difference between the microphone readings in these two flow regimes was strongly correlated to the distortion level and could therefore serve as the feedback signal to a controller. This approach led to a successful demonstration of an active flow control system that maintained a specified distortion level during a simulated transient flight condition.

The Air Force is designing aircraft, such as UAVs, smaller and more volume-constrained in order to meet stringent performance and cost requirements. Because the propulsion system often drives the size of these aircraft, UAVs will require highly integrated propulsion systems that complement emerging engine technologies to achieve vehicle performance and cost goals.

Researchers require next-generation inlet systems to be compact and ultra-efficient for UAVs. Additionally, these inlet systems must be winding and serpentine (wavy, resembling a serpent) to be less observable to enemy radar.

Traditionally, as inlets become shorter and more serpentine, aerodynamic performance suffers. To overcome these problems in the past, engineers used complex, costly, and heavy techniques such as boundary layer suction.

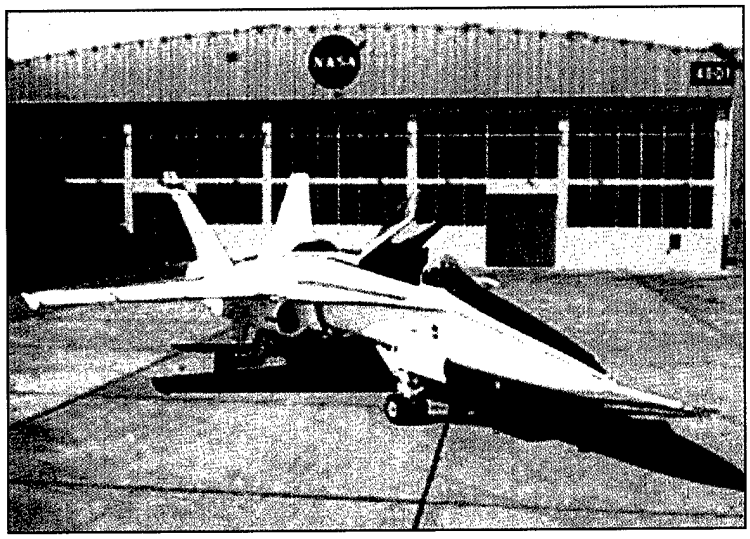
Recent studies in active flow control demonstrate that using small inputs to create large changes in flow structure can control flows in compact serpentine inlets. Active flow control is an enabling technology for highly compact inlet systems that allows a reduction in system weight and cost while maintaining the high performance of traditional inlets.

AAW Program Flight Tests Wing Warping

Beyond maneuverability, wing warping holds the promise of enabling thinner, higher-aspect ratio wings, resulting in reduced aerodynamic drag and allowing greater range or payload and improved fuel efficiency. It may also reduce the need for horizontal tail surfaces, even to the point of elimination.

If the Air Vehicles Directorate's Active Aeroelastic Wing (AAW) program proves successful, it could influence the design of future military aircraft like manned or unmanned long-range strike platforms and the United States Air Force's (USAF) conceptual SensorCraft high-altitude intelligence, surveillance, and reconnaissance platform. Program officials hope to obtain roll performance at transonic and supersonic speeds close to that of production F/A-18s, without deflecting the stabilators and with smaller control surface movements.

The directorate and its partners successfully rolled out the modified F/A-18A test aircraft recently at the National Aeronautics and Space Administration's (NASA) Dryden Flight Research Center, Edwards Air Force Base, California. The directorate conducted flight tests to prove that lighter, flexible-wing designs can control wing warping at high speeds and enhance aircraft maneuverability.



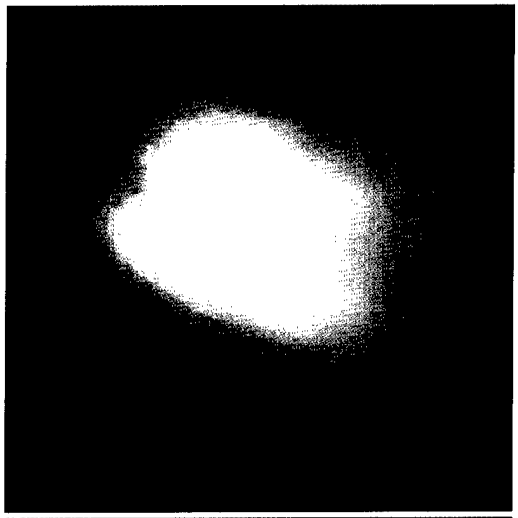
The platform features additional actuators, a split leading-edge flap, and thinner wing skins that allow the outer wing panels to twist up to 5°. The pilot will use the traditional wing control surfaces—the trailing-edge ailerons and the outboard leading-edge flaps—to provide the aerodynamic force needed to twist, or warp, the wing.

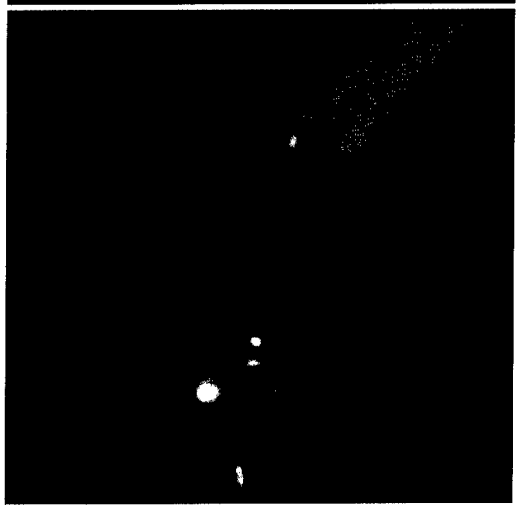
These tests form part of the AAW program, a joint effort between Boeing's Phantom Works, the directorate, and NASA. The project demonstrates aircraft roll control through aerodynamically induced wing twist on a full-scale aircraft at transonic and supersonic speeds. The AAW program builds on previous work by industry, NASA, and the USAF, including extensive wind tunnel testing of scaled models and conceptual studies.

High-Resolution Satellite Imagery from the SOR 3.5 m Telescope

The extremely high resolution of images collected by the Directed Energy Directorate's Starfire Optical Range (SOR) 3.5 m telescope and adaptive optics system demonstrates unprecedented atmospheric compensation capabilities for both imaging and laser weapons. Real-time compensated images show resolutions very near the theoretical limit of the telescope, enabling improved imaging performance for space surveillance and satellite diagnostics. The adaptive optics capabilities demonstrated are vital for effective laser weapons.

Modifications to the SOR's 941-channel adaptive optics system and telescope control systems produced significant improvements in atmospheric compensation performance. Images of low-earth orbit satellites showed resolutions very near the diffraction limit of the telescope (theoretical performance limit based on aperture size). This represents nearly complete elimination of atmospheric turbulence effects as well as correction of optical system flaws.





The SOR is an advanced optical research site, located at Kirtland Air Force Base, New Mexico, to develop advanced optical wavefront control technologies. Research focuses on field experiments in adaptive optics to compensate for the effects of atmospheric turbulence upon lasers and imagery. This technology is key for both real-time space imaging and a variety of laser weapons applications.

Equipment includes three major optical mounts: a 1.0 m beam director, a 1.5 m telescope, and a 3.5 m telescope, all capable of tracking low-earth orbit satellites. The 3.5 m telescope, equipped with a 941-channel adaptive optics system, is currently the largest and highest performance atmospheric compensation system in the world. The 3.5 m telescope/adaptive optics combination is highly successful, producing images of stars and satellites with resolutions approximately 65 times better than normal images.

Directorate researchers designed and integrated the adaptive optics system in-house at the SOR using a 941-actuator deformable mirror. Xinetics Corporation built the mirror.

Directed Energy Directorate Tests the Boeing Advanced Tactical Laser Demonstrator

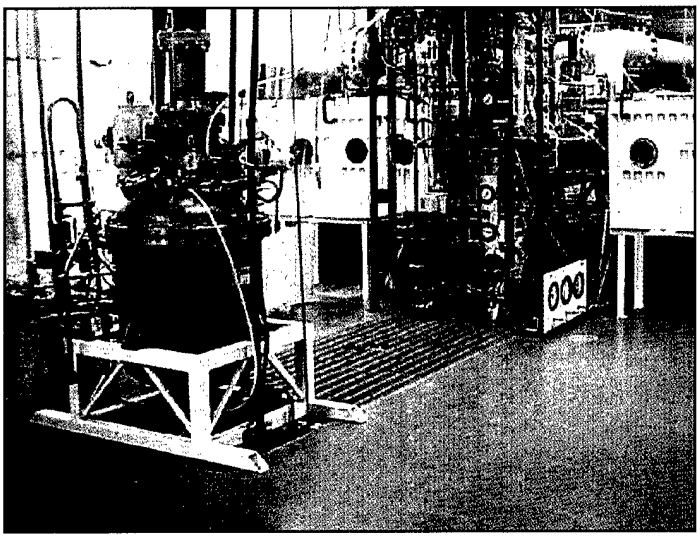
Directed Energy Directorate scientists and engineers operated the Advanced Tactical Laser (ATL) Demonstrator for the first time, achieving a "first light" of 600 watts (W).

Within days of operating the ATL Demonstrator for the first time at 600 W, the power level rose to 7,000 W. In two consecutive tests a few months later, the laser performed at greater than 14,000 W of average power over 8 sec shots, with peak powers approaching 16,000 W. Directorate scientists and engineers continue to explore the operating parameters of the laser in an effort to increase its operating efficiency. In addition, directorate engineers modified the laser's operational characteristics to increase the mission suitability of the laser as well as its magazine depth to support the ATL Advanced Concept Technology Demonstration (ACTD).

Directorate engineers and scientists tested the Boeing ATL Demonstrator in the Davis Advanced Laser Facility (DALF) at Kirtland Air Force Base, New Mexico. The ATL is a closed-cycle chemical oxygen-iodine laser developed by Boeing using internal research and development funds.

Boeing engineers briefly tested the device in their chemical laser test facility at Santa Susanna, California. During the course of those tests, the laser demonstrated 20,000 W of power.

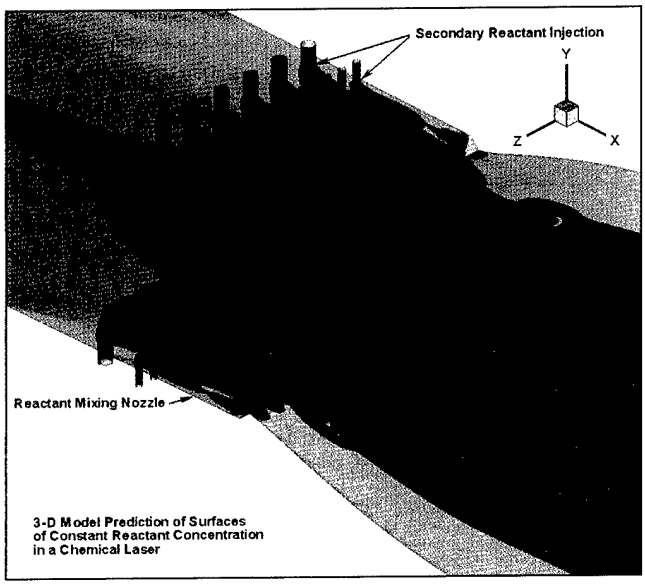
The directorate's High Power Gas Lasers Branch received funding from the Office of the Secretary of Defense-Joint Technology Office for a 2-year program to ship the laser to the DALF for further testing and evaluation as part of a risk reduction effort for the ATL ACTD.



Directed Energy Directorate Demonstrates a Powerful New Method for Chemical Laser Simulation

Project Directed Energy Directorate engineers demonstrated a new and powerful method for simulating high-power chemical lasers. Testing of chemical laser simulation models using the commercial software package GASP, from AeroSoft, Inc., demonstrates a 350% improvement in computing capability over previously used software.

Accomplishment The directorate's High Power Gas Lasers Branch demonstrated significant improvements in the modeling and simulation of high-power chemical lasers. Directorate engineers, using Air Force Office of Scientific Research funding, modified the commercial software package GASP to include physical models pertinent to chemical laser simulation and incorporated the software into current chemical laser research activities. Directorate engineers demonstrated a 350% improvement in computer capability over previous software during testing of chemical laser simulation models utilizing GASP on Department of Defense High Performance Computing Modernization program supercomputers.



3-D Model Prediction of Surfaces of Constant Reactant Concentration in a Chemical Laser

Background The directorate performs three-dimensional (3-D) simulations of chemical lasers including the chemical oxygen-iodine laser, the hydrogen-fluoride/deuterium-fluoride laser, and the recently demonstrated all gas phase iodine laser. These simulations explore the intricacies and complexities of chemical lasers by directly modeling the complex couplings between fluid dynamics, mixing and reaction of chemical fuels, and the extraction of photons during lasing.

The detail of these simulations generates information about these lasers that is difficult, if not impossible, to generate in experiments. This detail comes with a large cost in computer resources, and improvements in computational efficiency and capability serve to enable these simulations.

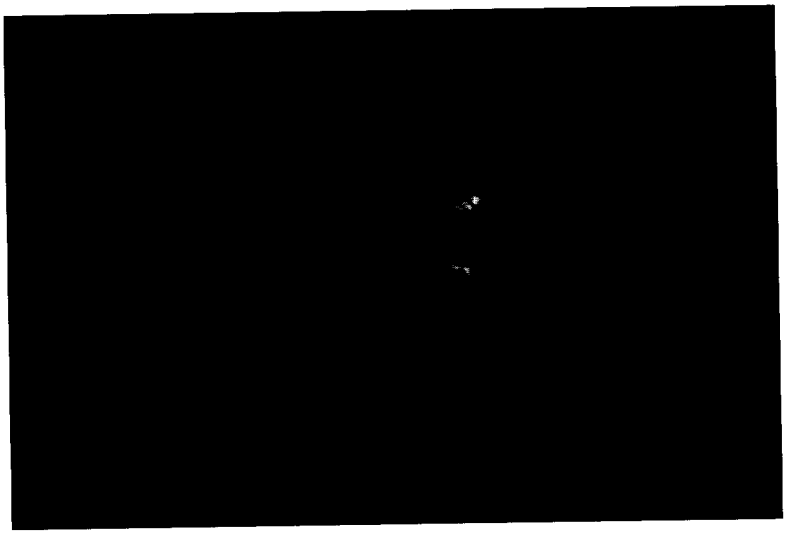
Through the careful application of these simulations, directorate engineers will identify pathways to higher chemical efficiencies and higher powers for testing in chemical laser systems. Such improvements translate into smaller and lighter chemical lasers, enabling the placement of these lasers into warfighter platforms such as the Airborne Laser and the Tactical High Energy Laser Fighter.

Air Force and Navy Dedicate New Relay Spacecraft Laboratory

Payoff The Optical Relay Spacecraft Laboratory, dedicated as part of a long-term agreement between the Directed Energy Directorate at Kirtland Air Force Base, New Mexico, and the Naval Postgraduate School in Monterey, California, will coordinate research and accelerate the development of new satellites such as the bifocal relay mirror spacecraft pictured here.

Accomplishment The Air Force and Navy recently dedicated the Optical Relay Spacecraft Laboratory at the Naval Postgraduate School, as part of a long-term agreement to coordinate research and accelerate the development of relay mirror technologies (mainly spacecraft specific). At the heart of the joint laboratory is experimental test equipment developed by Naval Postgraduate School Professor Brij Agrawal, his staff, and graduate students. Laboratory scientists will use the equipment to extend pioneering research by an Air Force and Navy team that established practical methods of satellite design, incorporating bifocal relay mirrors to transfer directed energy from lasers on the ground, in the air, or in space.

Background In a typical bifocal relay mirror, the unit directs a laser beam at a "receive mirror." That mirror collects the beam, passes it to a beam control system, which would "clean it up" optically, then refocuses and retransmits from a second mirror.



This would be a practical application for moving laser energy from one part of the earth to another–extending laser energy beyond the horizon, beyond the limiting confines of the earth's curvature. Bifocal relay mirror spacecraft offer a large number of potential missions beyond traditional reconnaissance such as giant "space flashlights" to light up future battlefields or enhance the efficacy of night-vision equipment.

Other uses include camouflage detection and penetration, laser communications to an airborne command post, creating a "laser fence" to detect low-visibility aircraft, theater wind profiling, tunnel and underground structure detection, and cloud ceiling detection. Bifocal relay mirror spacecraft still need technology developments in coupled attitude controls and beam control systems that can maintain a dual line-of-sight.

Directed Energy Directorate Achieves 6 Watts of Output Power from Initial Tests of its Mesospheric Sodium Excitation Source

Payoff Scientists and engineers produced 6 watts of continuous power in a high-quality yellow laser beam. When projected into the sky, the 589-nanometer (nm) wavelength beam will excite sodium atoms resident in the mesosphere to create a guidestar at about a 90-kilometer altitude. Large ground-based telescopes equipped with adaptive optics use guidestars to remove distortions caused by atmospheric turbulence and enable propagation of concentrated high-power lasers into space or high-quality, ground-based observations of space objects.

Accomplishment Scientists and engineers in the Directed Energy Directorate's High-Power Solid-State Lasers Branch and Starfire Optical Range produced 6 watts of continuous power in a high-quality beam at a wavelength of 589 nm. The engineers combined two invisible infrared lasers (1064 nm and 1319 nm wavelengths) within an optical cavity containing a crystal of lithium triborate to achieve this initial success.

The yellow beam exiting the lithium triborate crystal in the photo, which is reflected up at an angle by a "scraper" mirror, is visible because of Rayleigh scattering from nitrogen and oxygen molecules in the air. The beam's power is the highest ever demonstrated for a continuous-wave, sum-frequency-generated source and corresponds to an optical efficiency of about 55%.

Background In order to prevent projected laser beams from rapidly spreading, due to atmospheric distortion, and to achieve high intensity on target, one must remove the effects of the earth's atmospheric turbulence. An adaptive optics system can achieve this by observing an "artificial star" created high in the atmosphere, measuring the atmospheric distortion in the image of this guidestar, and then correcting for it 100 to 1000 times each second. The mesospheric sodium guidestar is especially useful for large (greater than 3 meters) ground-based telescopes because of its altitude and mobility.

The directorate will conduct sky tests with Starfire's 3.5-meter telescope. They will project the 10- and 50-watt beams to the mesosphere, overlap them, and measure the brightness of the resulting guidestar. The directorate will determine the best laser properties and build a facility-class laser for the telescope. The goal is to have the final laser operational on the telescope early in calendar year 2004.

The international astronomy community is also very interested in the development of this laser. The Gemini Observatory, a seven-nation partnership including the US, built two 8-meter, world-class telescopes, on Mauna Kea, Hawaii and at Cerro Pachon, Chile, to provide complete sky coverage of the Northern and Southern Hemispheres.

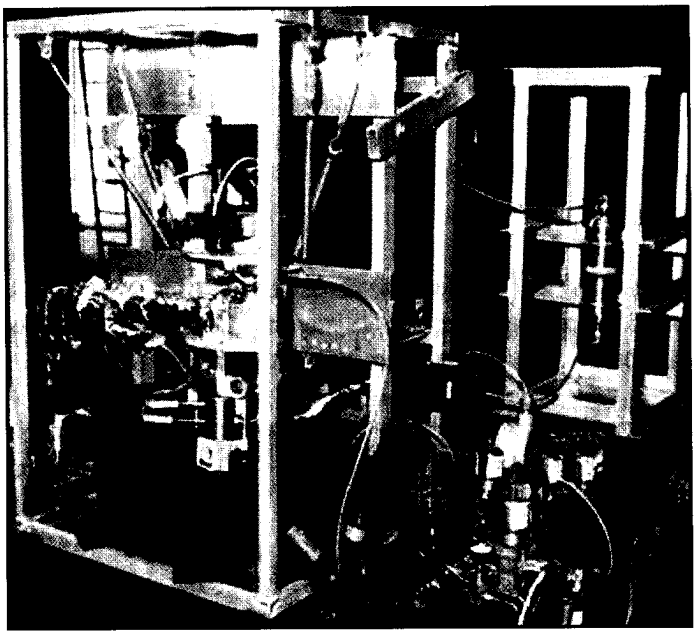
Both telescopes require sodium guidestars to achieve their full potential. The directorate established a Cooperative Research and Development Agreement with the Association of Universities for Research in Astronomy (AURA), to operate the telescopes for Gemini.

Toxicity of High-Energy Chemicals

Payoff A collaborative study between the Human Effectiveness Directorate (HE) and the Materials and Manufacturing Directorate (ML), using cellular and computational studies supported by the Air Force Office of Scientific Research, enabled a risk assessment for new high-energy chemicals synthesized in the Propulsion Directorate (PR). Experimental testing by HE, combined with the theoretical work by ML, can reduce the time and cost of toxicity evaluations for potential new propellants.

The combined experimental and computational studies outlined a paradigm for a first-level toxicity screening of new chemicals and propellants of interest to the Air Force. A potential replacement for the highly toxic hydrazine monopropellant is possible as a result of the synthesis and assessment of this new class of high-energy chemicals.

Accomplishment Drs. Tom Hawkins and Jerry Boatz, both of PR, designed a new class of hydrazine salts and, together with Mr. Adam Brand of PR, synthesized and characterized 13 high-energy chemicals. Drs. Saber Hussain and John Frazier, both of HE, in collaboration with Drs. Steve Trohalaki and Ruth Pachter, both of ML, carried out the test battery of end points and developed the Quantitative Structure Activity Relationship (QSAR) models. QSARs enable the screening of the new class of high-energy chemicals for potential toxicity and rank them with respect to hydrazine, a highly toxic monopropellant.

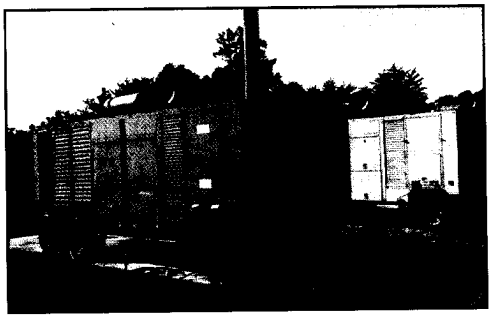


Background Researchers must often use animal tests to assess the toxicity of a chemical. However, due to the cost and time involved in toxicological assessments, early toxicity screening of new chemicals is important in predicting the adverse effects of chemical compounds. At the earliest stage of toxicity screening, biochemical toxicity end points, combined with computational studies, aid in decisions regarding development of novel chemicals, such as new propellants, by the Air Force.

HE scientists measured the following end points in primary cultures of isolated rat liver cells: mitochondrial function, lactate dehydrogenase leakage, generation of reactive oxygen species, and reduced glutathione content. The experimental results demonstrate that hydrazine-based compounds are more toxic than amine and triazole-containing compounds. Researchers could rank hydrazine-based compounds in order of decreasing toxicity with respect to hydrazine. Using theoretical calculated molecular descriptors, ML researchers derived QSARs for the biochemical toxicity end points. Application of the derived QSARs will assist in predicting toxicity for newly proposed propellants.

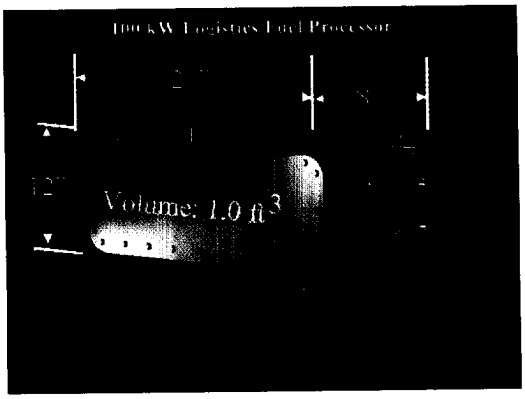
Materials Researchers Develop Fuel Processor Technology that will Enable Improved Power Generation at Remote Locations

Payoff The rapid evolution of fuel cell technology as a replacement for conventional electric power generators provides the potential for future power systems that use hydrogen as their primary fuel. The fuel processor will provide the user with efficient, easily operable, highly reliable, on-demand production of hydrogen at bare base locations. The compact and modular power generator, which consists of the fuel processor and fuel cell, will result in a 16% reduction in deployment airlift requirements and will offer lower emissions, infrared signature and noise levels, and a 50% reduction in power generation sustainment costs.



Accomplishment Materials and Manufacturing Directorate researchers are developing a deployable logistics fuel processor, which will permit the use of a reliable and easily operated fuel cell power system as an alternative to current mobile electric power (MEP) units. By replacing current MEP units, fuel cell technology, which uses hydrogen as the primary energy source, allows light and quick deployment of this important infrastructure element.

Background Today's mission requires a "light and lean" Air Force who must be prepared to rapidly deploy and indefinitely sustain forces to protect vital US interests. Operations abroad require mobile, air deployable infrastructure elements to stage and support land and air operations in remote locations.



MEP is one of seven essential deployment infrastructure elements. Overseas Air Force bases use MEP-12 generators, large 750-kilowatt generators driven by diesel engines, to provide electrical power. To support a contingent of 1,100 airmen, four 1,353-cubic-foot MEP-12 generators, which individually weigh 25,734 pounds, must be deployed, with one generator as a standby unit. This requires four transport aircraft and 4,000 gallons of fuel per day, which puts a severe burden on an already stressed air fleet.

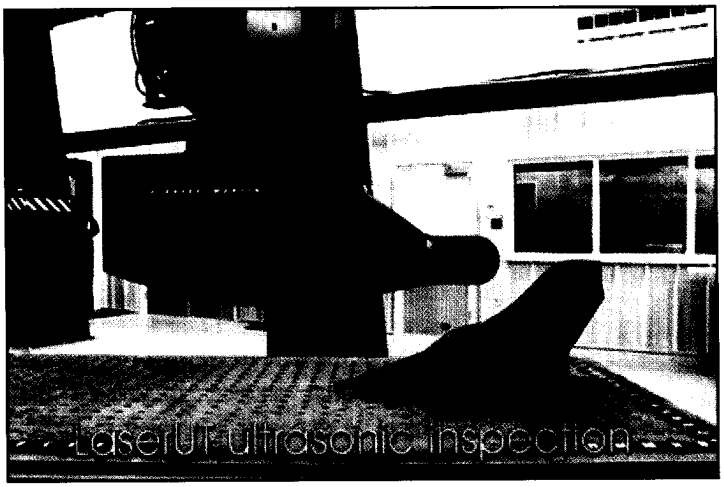
Researchers from the directorate's Air Expeditionary Forces Technology Division faced several challenges in developing fuel processor technology. Due to the potential pitfalls of sulfur content and coking while reforming heavy hydrocarbon fuels, such as JP-8 and diesel, effectively using battlefield logistic fuels as the primary energy source for fuel cells was difficult. Directorate researchers developed a fuel processor capable of removing all of the sulfur in fuel before it is reformed, producing ultra-clean hydrogen using hydrogen membrane technology. This reforming process also removes impurities such as carbon monoxide, carbon dioxide, and hydrogen sulfide.

In addition, the fuel processor developed in the lab uses an efficient radiant burner and a compact microchannel evaporator to produce the high pressure and high-temperature steam needed for the fuel reforming process. In order to recover water from fuel cell exhaust, which is 100% humid air, engineers also developed a compact condenser unit. The recovered water can be recycled and used for future reforming processes.

Laser Ultrasonic Technology Improves Composite Parts Inspections for Existing Fighter Aircraft

Payoff The Laser Ultrasonic Technology (LaserUT™) system requires minimal set-up time and performs high-resolution, composite parts inspections in a fraction of the time required by conventional water ultrasonic inspection systems. Steep reductions in inspection times will shorten manufacturing span times by several weeks, resulting in major cost savings for the Department of Defense. The LaserUT inspection system's improved accuracy enables even higher standards of quality for the Air Force and commercial aerospace sector.

Accomplishment A new aircraft composite parts inspection system, developed with support from the Materials and Manufacturing Directorate, will reduce the time required to inspect composite parts by up to 90%. The LaserUT system, developed by Lockheed Martin Aeronautics Company with technical assistance from the directorate's Nondestructive Evaluation Branch, enables affordable, highly accurate, high-volume inspection of complex-contoured composite parts for existing fighter aircraft. Long-term benefits for the Air Force include improved parts quality, shorter production times, and several hundred million dollars in savings over the lifetime of major aircraft acquisition programs.


LaserUT ultrasonic inspection

Background Existing fighter aircraft will have a high percentage of graphite-epoxy composite materials in their structures because these materials offer a high strength-to-weight ratio and extended service life. Extensive inspection is required, however, to ensure no flaws exist in the many layers that make up the finished components.

The Lockheed Martin Aeronautics Company, with technical assistance from directorate scientists and engineers, began inspecting composite aircraft parts using the patented LaserUT inspection system. This effort marked the first time Lockheed Martin engineers inspected aircraft composite parts using the advanced laser testing system, following years of research and prototyping by Lockheed Martin Aeronautics and its predecessors.

The LaserUT effectively handles complex-contoured components up to 54 ft long, 27 ft wide, and 21 ft high. A supercomputer, capable of advanced, real-time signal processing and data analysis, controls the equipment and also has a user-friendly operator interface that provides state-of-the-art ultrasonic flaw detection. The system provides real-time feedback to the system operator, or design and process engineers, facilitating rapid configuration and process changes.

The Lockheed Martin Aeronautics Company is continuing its research and development of the LaserUT inspection system in an effort to further reduce inspection times and meet affordability requirements. Directorate engineers expect the LaserUT to save several hundred million dollars over the operational lives of existing fighter aircraft programs due to greatly increased parts throughput. For example, using conventional parts inspection equipment, it takes about 24 hours to fully inspect a composite inlet duct on an advanced fighter aircraft. Using LaserUT technology, directorate engineers reduced the time to less than 2 hours, representing a 90% reduction in test-cycle times.

Cost-Effective Air-Sparged Hydrocyclone Technology Provides Treatment for Problematic Waste Streams

Payoff Air-sparged hydrocyclone (ASH) technology will provide the Air Force with significant cost savings compared to current practices associated with treatment of waste streams generated by a variety of Department of Defense (DoD) activities. The ASH system works well with streams containing oil and grease, aqueous film forming foam (AFFF), and in streams containing a combination of these contaminants.

The cost of operating ASH technology, including the cost of consumables and utilities associated with the system, ranges from $.17 per 1,000 gallons treated for AFFF treatment with no chemical treatment to $2.54 per 1,000 gallons treated for extremely high oil and grease concentrations with chemical pre-treatment.

Accomplishment Scientists at the Materials and Manufacturing Directorate, under a collaborative effort with the Naval Facilities Engineering Service Center and the contractor, Kemco Systems, Inc., developed a cost-effective ASH technology to treat waste streams containing emulsified petroleum-based substances such as fuels, oils, and greases. This time-saving technology can also treat fire-fighting chemicals, such as AFFF, used to suppress combustible and flammable liquid fuel fires.

Background Anxious to test the ASH technology, researchers developed a field test/demonstration project to validate the effectiveness of the ASH system at removing emulsified fuels, oil, grease, and AFFF from waste streams generated at nine DoD sites. The objective of the project was to demonstrate the commercial viability of the system and allow an audience to witness the operation of the technology, opening doors for transfer of the technology to other DoD agencies and industry.

The ASH system works by combining flotation principles with the separation characteristics of a hydrocyclone, which separates fuel, oil, and grease from water. In the case of fine particles and oil removal, the ASH system improves the ability of fine particles and oil droplets to float.

The ASH system effectively and efficiently removed emulsified oil, grease, and AFFF from waste streams with an average removal rate of greater than 87% for oil and grease removal and greater than 90% for AFFF removal. The researchers also achieved these results in cases of high AFFF concentration (over 500 parts per million).

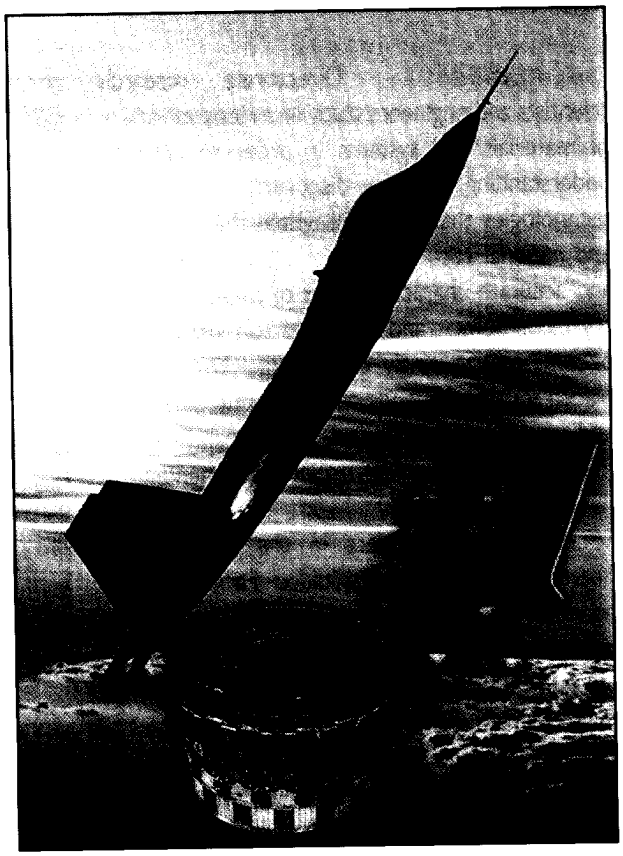
The concentrated sludge remaining from ASH processing is less than 10% of the original stream volume and, in many cases, lower than 7%. Researchers conducted toxicity-leaching tests on this sludge and classified the sludge as non-hazardous.

Turbine Engine Exhaust Casing Redesign Provides Affordability and Durability

Payoff Under a contract with the Materials and Manufacturing Directorate's Manufacturing Technology Division, Pratt & Whitney (P&W) has successfully redesigned the F119 engine's turbine exhaust case (TEC) and predicts initial cost savings of at least 35% using the new casting process. P&W also expects the process to improve aircraft engine durability with decreased maintenance downtime, resulting in an increased mission-ready status. With the success of the TEC program for the F119 engine of the F-22, the Air Force is looking at this technology for use on engines for other aircraft.

Accomplishment The redesign makes extensive use of thin wall castings in place of the existing complex, multi-walled, and diffusion-bonded sheet metal assemblies. It provides a significant reduction in cost and improved durability, while maintaining weight parity with the former sheet metal design.

Background The TEC on a jet engine, located just aft of the turbines, directs the exhaust of the turbine in a particular flow pattern out the rear of the engine. Directorate engineers believed the TEC vanes is one area for improvement with a fairly high degree of success. Original built-up sheet metal components comprise much of the cost in the engine due to the need for laser cutting and drilling, welding, brazing, assembly, and more. This makes the TEC a labor-intensive section of each engine.



The Reproducible F119 TEC Castings program directly supports an alternate manufacturing approach for the F119 TEC, which makes extensive use of thin wall casting technology in the Initial Service Release design. Development and incorporation of thin wall castings eliminates many subassembly details and manufacturing processes by designing simplified cast details that serve the same function as the complex sheet metal subassemblies.

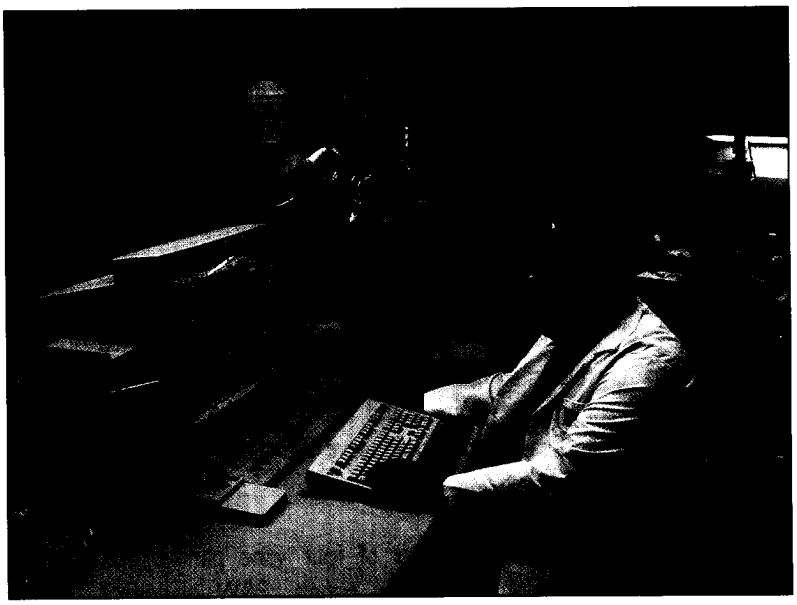
The cast TEC vane section consists of four vane panels, box assemblies, inner and outer diameter panels. P&W engineers assembled a total of 16 vane airfoil segments around a ring-strut-ring-configured frame to complete the TEC. The engine manufacturer uses a nickel-based alloy to create the cast TEC that offers higher temperature capability over Waspalloy used in sheet metal construction. The majority of the TEC panels are iso-grid designs requiring thin walls (0.025 in. nominal with a tolerance of plus 0.010 in., minus 0.007 in.).

Focused Ion Beam Microscope Improves Aerospace Materials Characterization

Payoff The Materials and Manufacturing Directorate acquired an advanced microscope that greatly enhances the facility's capability to research and develop new materials for current and future aerospace systems. Designed around the basic functions of a focused ion beam (FIB) and a scanning electron microscope (SEM), the new instrument significantly improves materials characterization by combining nano-machining, micro-deposition, and micromanipulation capabilities with simultaneous imaging, using both ion and electronic optics.

Accomplishment Researchers at the directorate's Microstructural Characterization Facility, collaborating with faculty at the Ohio State University, the Air Force Office of Scientific Research (AFOSR), and FEI, Inc. (formerly Phillips Electron Instruments), helped develop the critical concepts required to build this next-generation laboratory instrument. The newly acquired microscope is a powerful tool for analyzing the difficult, complex materials systems routinely encountered by directorate researchers. The new instrument allows for novel high-resolution characterization studies and helps reduce sample preparation times from weeks to hours, which results in substantial savings for both in-house and shared resource users.

Background Directorate research scientists and engineers study an extensive variety of materials and systems in order to enhance understanding, assist in discovery, and advance technologies that help strengthen the Air Force and national security. This effort includes timely and accurate characterization of microstructure, crystallography, and chemistry, which are becoming increasingly diversified. This growth placed several demands on directorate personnel and resources, particularly in research-critical microstructural characterization instrumentation.



Scientists and engineers in the directorate's Microstructural Characterization Facility (MCF) needed new analytical tools that are more sensitive, user-friendly, computer controlled, and efficient due to the intrinsically diverse nature of materials discovery and expanding levels of microstructural control and manipulation. The MCF Team also knew these tools must address large numbers of materials classes and systems and must drastically reduce the amount of time needed to prepare samples. Improved characterization capability was clearly the best solution.

Researchers at the directorate's MCF, collaborating with the Ohio State University faculty and AFOSR, assisted FEI in the successful development of the dual-beam FIB-SEM. The new FIB-SEM incorporates many of the versatility qualities eagerly sought by characterization equipment developers, while offering outstanding potential as a shared resource among partnering centers of excellence. For example, the new microscope contains numerous analytical sensors for chemistry and crystallography as well as process controls and digital data acquisition via user-friendly computer interfaces.

Directorate Develops Software-Based Modeling Tool that will Aid Materials Qualification of Textile and Preform Composites

Payoff A software-based analytical tool for textile and preform composites will save manufacturers time and costs related to materials qualification by supplying reliable information about the strength, stress, and complex three-dimensional (3-D) failure modes. This information will allow manufacturers to quickly produce and incorporate the emerging lightweight, low-cost, load-bearing structural materials needed to sustain present and future Air Force aviation, space, and munitions applications.

Accomplishment Engineers from the Materials and Manufacturing Directorate developed a software-based analytical tool that will supply engineers and composite manufacturers with important materials qualification information about the stress, failure initiation, failure modes, and strength of textile and preform composite materials. Materials manufacturers already experienced success using the model to determine the structural characteristics of 3-D woven textile composites.

Background Working with composite materials, directorate engineers discovered that traditional composite laminates, containing no fiber reinforcement in the thickness direction, are as delamination resistant as a textile composite with woven or braided fibers. Weaving fibers in three dimensions increases the damage tolerance, impact resistance, through-the-thickness strength, and stiffness of the composite.

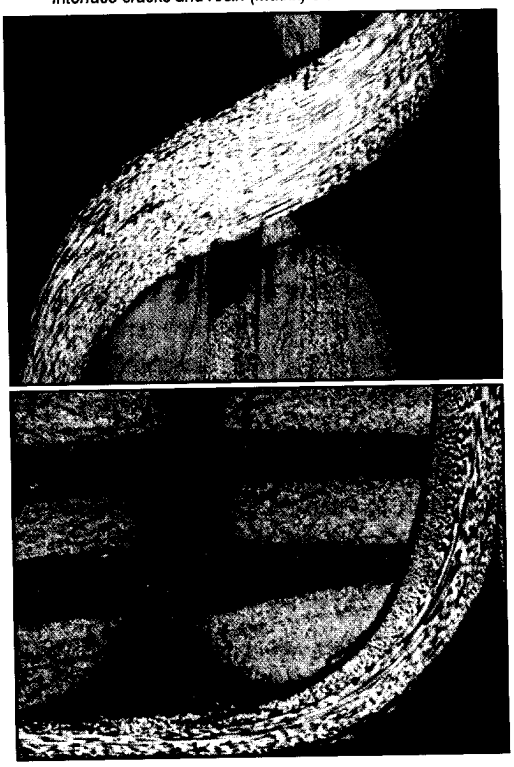
Preform (textile) composites enable low-cost manufacturing processes (such as vacuum-assisted resin transfer molding) for fabricating structural components of complex shapes. Thus, textile composites are becoming a widely used and affordable medium in advanced composite manufacturing.

Manufacturers use textile composites as the key material forms to produce the complex shapes and structures that exist in cutting-edge Air Force aviation, space, and munitions applications. However, engineers face challenges analyzing the structural performance of 3-D curved fiber reinforcements (yarns).

Engineers from the directorate's Structural Materials Branch developed a numerical modeling tool, which runs on a software application that combines the stress analysis of 3-D curved fiber yarns in conjunction with finite element analysis. Manufacturers provide the fiber-reinforcing direction (fiber yarn direction), its dimensions, and properties of the fiber and matrices.

Next, the model calculates the stresses experienced by a fiber yarn and the matrix material when a load is applied. With the strengths of the fiber and matrix defined, researchers can conduct trend prediction to determine how cracks or failure will initiate.

Micrographs showing cracks in 3-D preform composites. In these micrographs, smooth regions are the resin (matrix) regions with surrounding 3-D curved reinforcing yarns. Interface cracks and resin (matrix) cracks are visible.



Advancements in Conductive Adhesives Improve Aircraft Microelectronics

Payoff This Small Business Innovation Research (SBIR) program should result in the successful development of a highly thermal and electrical conductive adhesive that meets rigorous Air Force radio frequency (RF) microelectronics environmental requirements. This includes flexibility under thermal cycling, dimensional stability upon cure, and good adhesion coupled with easy rework—even under hot, wet, and a variety of other environmental exposure conditions.

The continuous fiber z-axis orientation ensures the adhesive is immediately applicable in commercial electronics as a replacement for the Anisotropic Conductive Films used in liquid crystalline displays and solder balls used in flip-chip packaging (the fastest growing sector of commercial integrated circuit packaging).

Accomplishment Engineers at the Materials and Manufacturing Directorate, working with Browne Technology, Inc. of Longmont, Colorado, under an Air Force SBIR program, developed a polymer-based adhesive formulation to improve the performance of conductive adhesive materials used in RF microelectronics for advanced fighter aircraft. They demonstrated an innovative formulation to significantly increase the adhesive's thermal and electrical conductivity compared to existing polymeric adhesives, but at a comparable cost. The new adhesive formulation also eliminates certain unique Air Force microelectronics assembly and processing requirements, resulting in considerable production cost savings.

Background Advanced electronic devices, including those used in microelectronics for advanced fighter aircraft, generate more heat because increases in performance translate into increases in power density. To avoid temperature damage, advanced electronic devices must remove this increased heat, hence the need for better thermally conductive adhesive materials.

Adhesives currently available for Air Force microelectronics applications require many hours of pressure and enclave cycle time to cure properly, making the bonding process very time consuming. Although adhesives with enhanced properties are commercially available, they have proven unsatisfactory, since they are either incompatible with the subsystem's automated assembly process or difficult to handle. Complicating matters further, the quick setting, alternative adhesive materials now available, that are automatically dispensable, cannot withstand repeated thermal cycles of -40° to +100°C under operational conditions without premature failure.

The Phase II effort will concentrate on developing a prototype process to produce adhesive in a continuous, reliable manner in film pieces at least 3 in. by 24 in. The emphasis will integrate the adhesive processing capabilities with current RF microelectronics assembly processes to ensure maximum reduction of production assembly costs. Continued success during the SBIR Phase II effort could lead to significant improvements in microelectronics for advanced fighter aircraft and expanded application of the new conductive adhesive throughout the Department of Defense and the commercial electronics industry.

High-Resolution Digital Flat Panel X-ray Detector and Software Offer ALCs Improved NDI Technology

Payoff Digital radiography provides personnel at the Air Logistics Centers (ALCs) with highly improved nondestructive inspection (NDI) tools for evaluating complex aircraft structures. Digital radiography (DR) technology offers significant advantages over conventional film-based radiography including offering a wider dynamic range (thickness range) and eliminating the need for film development and associated hazardous chemicals.

DR technology provides real-time data acquisition by acquiring and displaying digital images on a computer screen in a fraction of the time it takes to produce similar film images, typically around 15 seconds depending on the application. The technology also enables instant data retrieval, storage and sharing of data, and possibilities for equipment automation. It may allow technicians to evaluate and work on multiple areas of the aircraft simultaneously.

Accomplishment Researchers from the Materials and Manufacturing Directorate demonstrated the use of a high-resolution digital flat panel X-ray detector and its respective software. Directorate researchers expect this technology to improve and simplify nondestructive radiographic inspection of aircraft airframes and structures and provide high-resolution capability, enhanced performance, improved productivity, and reliability over conventional film-based radiography methods.

Directorate researchers traveled to the ALC at Hill Air Force Base, Utah, to conduct DR systems' training sessions for depot production radiography personnel. The successful demonstration of DR technology aids the transition of this technology in the Digital Radiography Insertion Program (DRIP). The DRIP focuses on specific Air Force depot application for digital radiography use to improve depot inspection capabilities and the practice of timely methods.

Background Aircraft workers use radiography inspection during aircraft manufacturing, maintenance, and repair to locate structural features and hidden anomalies such as cracking, corrosion, foreign object damage, voids, and moisture in aircraft structures. Engine manufacturers also use this technology extensively during the manufacturing of aircraft turbine engine components to detect and evaluate cavities, micro-shrinkage, porosity, inclusions, and cracking.

Under a contract with the directorate's Nondestructive Evaluation Branch, General Electric (GE) Corporate Research and Development Center, Advanced X-ray, Inc., and Varian, Inc. evaluated and assessed performance and delivered products for digital radiographic use in the NDI of aircraft structures. NDI and evaluation of aircraft eliminate the need for unnecessary maintenance and aircraft disassembly, which have the potential for creating additional damage and problems in aging Air Force systems.

Researchers from GE and the directorate tested and evaluated commercially available digital panels to determine if the products met criteria required by the ALCs including the resolution of images taken by the panel (penetrameters and line pairs), active viewing area size, pixel pitch (pixel size), and imaging of real aircraft parts. The Varian 4030 amorphous silicon flat panel detector emerged as the detector of choice.

Team Demonstrates and Validates Commercial, Portable Handheld Lasers for Paint Stripping and Coating Removal

Payoff Using pulsed lasers for paint and coating removal during inspection, maintenance, and nondestructive evaluation work offers the Air Force a non-abrasive process that eliminates the need for potentially hazardous chemicals that create liquid waste. This process also offers increased safety and time advantages over current coating removal processes.

Laboratory experts expect that successful demonstration and evaluation of the lasers will lead to application of laser stripping processes for use by technicians at Department of Defense maintenance depots and Air Force Air Logistics Centers. The process will supplement existing depainting processes in an effective, environmentally safe manner.

Accomplishment A team from the Materials and Manufacturing Directorate and the Air Force Materiel Command (AFMC) demonstrated and validated commercially available, portable handheld lasers for coating removal. The technology demonstration and validation program, part of the Joint Group on Pollution Prevention process, is a partnership between various government organizations to validate and implement cleaner and cheaper processes at military and industrial facilities.

Background Commercial and military aircraft frequently need paint stripped to allow for inspection, maintenance, and nondestructive evaluation work. Off-the-shelf, pulsed laser systems offer significant benefits as a non-abrasive coating removal process.

Pulsed lasers work by emitting a series of brief energy bursts while aimed at the surface of a coated material. These lasers remove coatings applied to the material by applying energy. On aircraft materials, technicians can use the laser to remove multi-layered paints, primers, or other special coatings. Aircraft workers repeat this process until reaching the desired depth and tailor the system to strip at a specific depth to remove single layers of coating or paint while others remain intact.

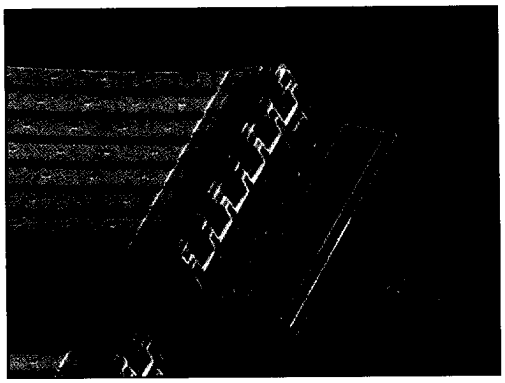
Directorate engineers began the prototype for this project in 1998, based on requirements of the Environmental Safety and Occupational Health Technology Integrated Product Team, now the Environmental Development Planning Team. In 2000, the directorate's Pollution Prevention Research and Development Team and AFMC's Logistics Environmental Branch teamed to identify the prototype technology and begin the demonstration, validation, and technology transition process based on a Joint Test Protocol (JTP). The JTP is a set of requirements used to qualify available commercial off-the-shelf systems to meet joint service and National Aeronautics and Space Administration needs.

Technicians from the directorate's Survivability and Sensor Materials Division's Laser Hardened Materials Evaluation Laboratory began demonstrating the capabilities of two neodymium yttrium alumina garnet laser-cleaning machines. These machines are capable of producing 120 watts (W) of average power. They contain a diode laser with power capabilities reaching to 250 kilowatts of average power and a carbon dioxide laser with an average power of 520 W.

Lubricant Extends Operational Life of Microelectromechanical Systems

Payoff Microelectromechanical systems (MEMS) represent an enabling technology for a number of systems important to the Air Force and national security and are particularly important for miniaturization, integration, and enhancing capabilities in spaceborne military systems. They also benefit commercial industry.

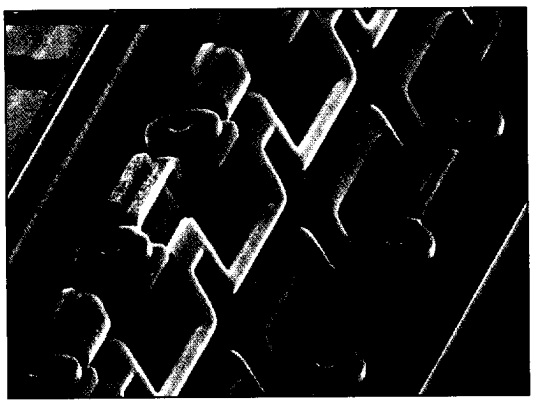
Hard-coat lubricants and effective application processes can increase the working life of MEMS. Examples include miniature satellites, airflow control, sensors, actuators, accelerometers, gyroscopes, microwave switches, aircraft turbine engines, and unmanned air vehicles.



Accomplishment Scientists at the Materials and Manufacturing Directorate's Nonmetallic Materials Division, working with Surmet Corporation and the University of Dayton Research Institute (UDRI), developed a protective hard coating and conformal application process under a Small Business Innovation Research (SBIR) program and successfully demonstrated it on an electrostatic lateral output motor using a post-deposition process developed in house. This coating can extend the operational life of MEMS used on aerospace and space systems.

Directorate engineers developed this new lubricant coating specifically for miniature electrical and mechanical devices used by the Air Force. Their achievement demonstrates that hard-coat lubricants are effective in reducing friction, wear, and other phenomena that hinder the development and sustained operation of MEMS devices.

Background MEMS are batch-fabricated miniature systems containing electrical and mechanical components on the millimeter to nanometer scale. Their primary advantage over conventional systems is an ability to drastically reduce the size, weight, power consumption, and cost of the aerospace and space systems they support.



MEMS technology and processes include lithography, bulk micro-machining, surface micro-machining, etching, film deposition, and packaging. Examples of structural materials used to build MEMS include polysilicon, silicon carbide, silicon nitride, and diamond. MEMS can enhance capabilities affecting flight safety and mission success. This is particularly true with respect to onboard diagnostics for aircraft and the reconfiguration of microsatellites.

Protecting MEMS against friction, wear, stiction, adhesion, and other phenomena that hinder performance and shorten operational life poses a significant challenge. Working with Surmet Corporation and UDRI under SBIR Phase I and II programs, the directorate's tribology research team successfully demonstrated a new hard-coat lubricant on an electrostatic lateral output motor.

The directorate selected the motor as the test base because it has a large electrode area, which provides a sufficient level of force, and has a variety of contact interfaces for tribological studies. It also ensures the relevancy of any lubrication scheme to MEMS and provides a platform for numerous interesting experiments.

Innovative Polymer Processing and Fabrication Techniques Increase Potential for Deployable Parabolic Reflectors

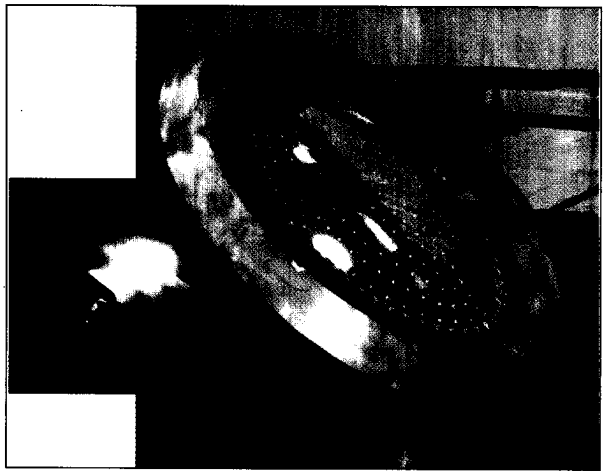
Payoff The innovative processing and fabrication techniques created and tested under a Small Business Innovation Research (SBIR) program increase the feasibility of constructing large, deployable, lightweight, inflatable parabolic concentrators for military and commercial applications. The thin film developed during the initial phase of this effort is more tear- and puncture-resistant than previously tested materials and less likely to fracture under stress. In addition, manufacturers can correct shape aberrations prior to cure, ensuring high quality outcomes and significant savings in material and production costs.

Accomplishment Engineers at the Materials and Manufacturing Directorate made significant advancements in developing large, lightweight, inflatable structures to deploy in space as reflectors for optical imaging, communications, and solar energy collection. Teaming with SRS Technologies, under an Air Force SBIR program, the directorate manufactured ultra-thin polymeric films with the net-shape precision and material toughness required to function as parabolic concentrators, not only in support of the Air Force, but also for a diverse range of commercial applications.

Background Researchers at the directorate's Nonmetallic Materials Division, Polymer Branch, working with SRS Technologies, demonstrated the feasibility of using a tough, new, fracture- and puncture-resistant, polymeric film in both clear and metallized forms. The film is only 0.4 mil (four-hundred thousandths of an inch) thick.

As part of the initial phase, they also developed and tested a mandrel that allows workers to correct aberrations in the film's shape (due to pressure and thermal loads) during the membrane casting process. The mandrel helps ensure that workers can inflate the polymeric film into a near-perfect net shape.

Directorate engineers tested the polymeric film at the Glenn Research Center in Cleveland, Ohio, under space environmental conditions. SRS engineers fabricated and characterized the film and mandrel at the SRS Technologies facility in Huntsville, Alabama.



The results showed the material is significantly more tear- and puncture-resistant and less likely to fracture than conventional thin films. The directorate used precision optical test methods and computational analysis to perform shape characterization of the mandrel and membrane. The tests also indicated that the new mandrel technology represents a major advancement in developing large, lightweight concentrators.

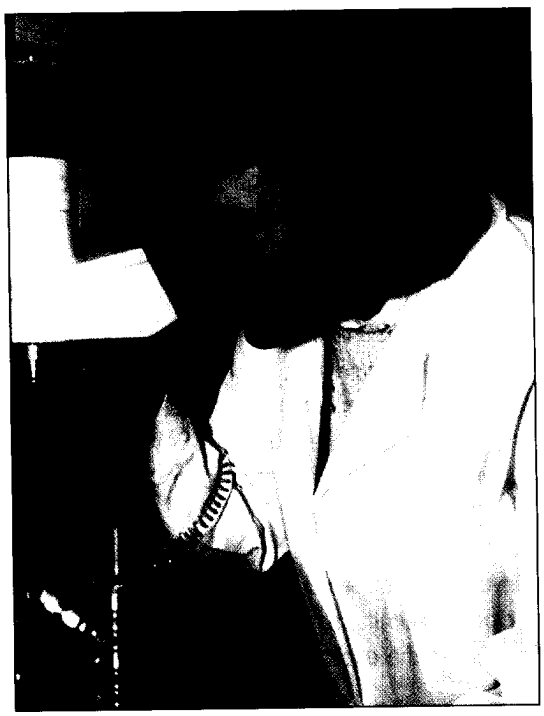
Based on the successful outcomes of Phase I of the SBIR, the directorate and SRS Technologies continue developing the processing and fabrication techniques. They will modify them, as needed, to ensure successful development on a larger scale.

Improved Lubricants and Additives Increase Operational Life of Space Mechanisms

Payoff Extending the operating life of military and commercial satellites would enhance the payback of each satellite launched, while reducing the costs associated with constructing and launching replacements. The knowledge that engineers at the Materials and Manufacturing Directorate gain through their research on improved base fluids and ultra-low volatility boundary lubrication/ lubricity additives will be a determining factor in selecting longer lasting lubricants and additives for future space systems.

Accomplishment Improved base fluids and ultra low volatility boundary lubrication/lubricity additive research could help extend the operational life of military and commercial satellites and enhance the reliability of their components. Directorate research efforts will lead the way to substantial reductions in cost by increasing the length of time future satellites can remain in orbit, and have significant implications for aviation and commercial industry application of liquid and grease lubricants.

Background As the use of satellites for military and commercial communication, navigation, and global surveillance applications continues to increase, the high costs for building and launching them are driving the need to extend their useful life from the current 5-8 years to 15 years and beyond. One of the most cost-effective ways to extend the lives of satellites is to improve the lubrication of their mechanical systems, resulting in more reliable and longer operating components.



Two factors are vitally important in retaining good lubrication in liquid/grease-lubricated systems over an extended period in vacuum environments. First, the lubricant base oil must remain in place—not volatilize or creep into other areas—and it must not change in other ways—become thicker or change chemically. Second, the additive(s) which provide or enhance many of the required characteristics must not evaporate, degrade, or be consumed.

Researchers at the directorate's Nonmetallic Materials Division evaluated three major classes of synthetic hydrocarbons for space applications including liquid/grease formulations with polyalphaolefins (PAOs), multiple alkylated cyclopentanes (MACs), and silahydrocarbons (SiHCs). The research effectively demonstrated that all three classes offer major advantages over conventional mineral oil lubricants for space applications. Four-ball and reciprocating tribometer methods, in a nitrogen environment, were key in demonstrating significant, improved lubrication performance from the candidate lubricants.

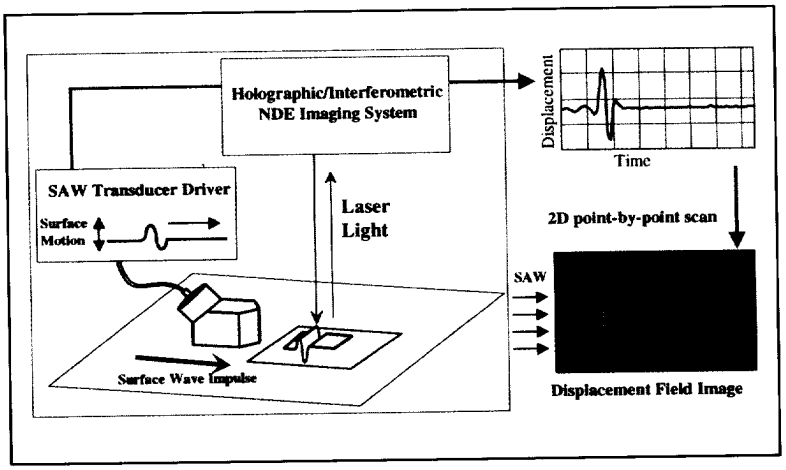
The fluids evaluated during the study—PAOs, MACs, and SiHC oils—are the best possible fluids in the hydrocarbon family for space applications (viscosity index, volatility, traction, change with evaporation, and availability must be considered for specific applications). The research team also found that additives show different levels of anti-wear effectiveness among the three base fluids and in the greases. In oils, for example, only long-term soluble additives are acceptable, but additive solubility is not critical for greases.

Advanced Imaging Systems Allow Visualization of Surface-Breaking Cracks

Payoff Advanced nondestructive evaluation (NDE) systems provide a new capability for imaging surface-breaking cracks that is both non-contact and remote in nature. Both systems characterize the cracks with microscopic resolution, which dramatically lowers crack detection limits and provides an opportunity to characterize surface-breaking cracks in full three-dimensional detail.

Compared to traditional and other state-of-the-art NDE techniques, the new laser ultrasonic systems provide increased sensitivity to local features, enhanced signal levels, and simplified characterization. This may permit researchers to monitor materials and structures more effectively for defects that, over time, could degrade integrity.

Accomplishment Scientists and engineers at the Materials and Manufacturing Directorate developed two advanced NDE systems for imaging and characterizing surface-breaking cracks in advanced aerospace materials. Developed with assistance from the University of Dayton's Center for Material Diagnostics, the new systems use laser ultrasonic principles to image microscopic cracks invisible to the naked eye and difficult to measure with traditional NDE techniques.



The systems use laser interferometry and holography principles to visualize cracks based on their near-field ultrasonic scattering signatures. This permits NDE technicians to observe detailed, microscopic images of the cracks that could have a significant impact on inspection processes for substrate materials and other structural components.

Background In the past, researchers extensively used surface acoustic waves (SAWs), one of the most commonly used techniques in NDE for surface-breaking crack detection and characterization. A typical measurement involves careful evaluation of SAW energy scattered from a defect site and noted by alterations in SAW amplitude/phase, reflection/transmission coefficients, and frequency content. The novel aspect of the new approaches is to measure the effects of the cracks on SAW propagation and scattering using non-contact laser interferometry and holography systems, which provided high-resolution, time-averaged displacement field images as their output.

Scientists and engineers in the directorate's Metals, Ceramics, and NDE Division, investigated three realistic surface-breaking cracks during this research effort: a thru-the-thickness crack in aluminum, along-surface crack in aluminum, and a 250-micrometer fatigue crack in titanium. In all three cases, researchers used a 10-megahertz SAW impulse as the excitation source, with the wedge-coupled transducer (1/4 inch diameter) positioned 2 centimeters from the cracks.

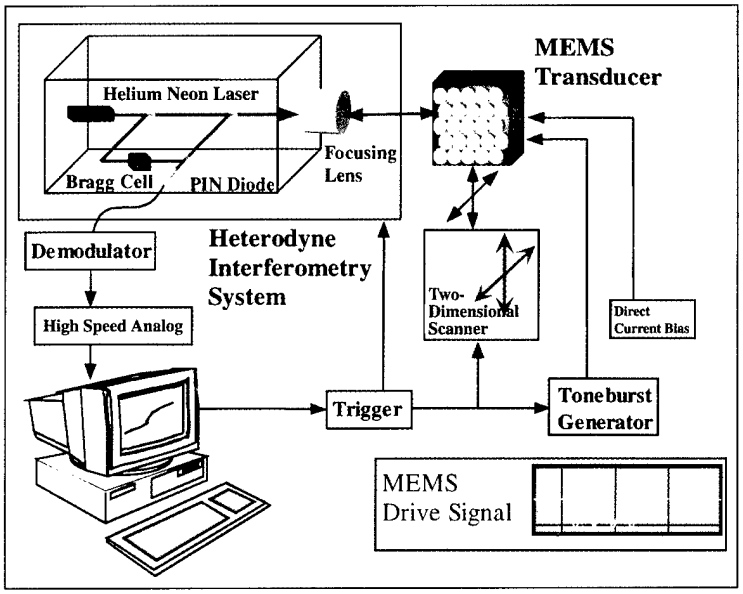
In all cases, the near-field displacements in the immediate vicinity of the cracks were much larger than the average displacements away from the cracks. This resulted in a dramatic brightness increase at the crack site when imaged using the interferometric and holographic NDE techniques. The measurement of out-of-plane displacement of scattered waves in the immediate vicinity of a surface-breaking crack using the NDE system provides a powerful method for detecting small cracks and studying near-field scattering effects.

Laser Technology Detects and Characterizes Miniature Transducer Defects

Optical diagnostic techniques offer an efficient means for conducting nondestructive evaluation (NDE) measurements for characterizing microelectromechanical systems (MEMS) and other miniature devices under study and evaluation.

Scientists and engineers at the Materials and Manufacturing Directorate demonstrated the feasibility of using lasers to detect and characterize defects in miniature transducers for use on military and commercial aircraft and space vehicles. The laser technology provides visual images of individual microelements in the transducers or entire array structures, allowing researchers to evaluate the transducers' performance and determine the improvements to make. Their methodology employs optical interferometric techniques to provide measurements of surface displacement levels and topography with sensitivities exceeding nanometer levels.

Characterizing MEMS and other microstructures and identifying defects in them, using traditional NDE techniques, is very difficult and poses a demanding challenge for the NDE community. Optical probe techniques using laser technology provide an avenue for making sensitive NDE measurements on microscales. Directorate scientists and engineers conducted a detailed microcharacterization of MEMS ultrasonic transducers—devices that convert one form of energy to another—using two advanced laser interferometry NDE techniques.



Sophisticated ultrasonic transducer microarrays, based on MEMS technologies, are quickly becoming a reality. In this investigation, the directorate's research team evaluated the performance characteristics of a MEMS ultrasonic transducer using a scanning heterodyne interferometry system and a white-light interference microscope system. The scanning interferometry system provided measurements of the dynamic response of the MEMS, while the white-light interferometry system provided static surface topography measurements.

The team made both types of measurements on microscales. They characterized individual micromechanical elements (nominally 50 micrometers in size) as well as the entire 28 x 32-element MEMS array device. The team observed variations of about 16% in the out-of-plane displacement levels across the device as well as non-responsive MEMS elements. They also observed possible evidence of cross-coupling of acoustic energy between adjacent MEMS elements.

Advanced Adaptive Autopilot JDAM Flight Tests

The Munitions Directorate's Navigation and Control Branch worked with Guided Systems Technologies (GST) on a Phase I Small Business Innovation Research (SBIR) project to demonstrate the Advanced Adaptive Autopilot (AAA) concept feasibility on the Small Smart Bomb airframe model. The recent Phase II SBIR project focuses on further development of the AAA concept for the Joint Direct Attack Munition (JDAM) family of weapons.

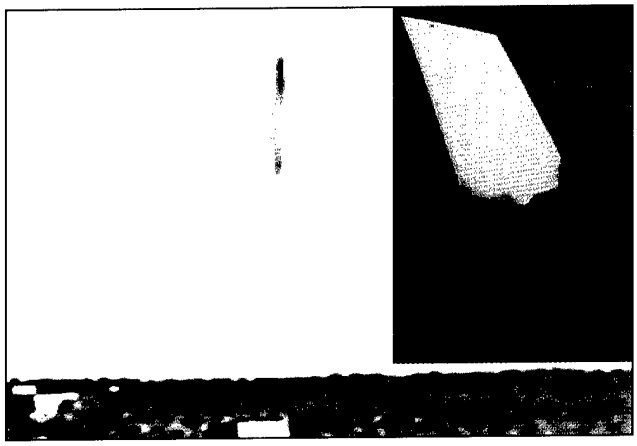
AAA is a neural network-based nonlinear adaptive autopilot capability. It will reduce the dependence on wind tunnel testing for flight demonstrations, munition configuration upgrades, and pre-planned product improvement developmental programs.

With support from Boeing (the JDAM prime contractor and a subcontractor on the Phase II SBIR project), GST and directorate engineers conducted two free-flight test missions to demonstrate the new autopilot technology, using updated Anti-Jam Global Positioning System (GPS) Technology Flight Test MK-84 tail kits. The AAA technology allows for the design of a new autopilot based upon only an approximate aerodynamics model.

AAA provides engineers the capability to rapidly prototype modifications to the airframe, or even new airframe variants, without costly and time-consuming high-fidelity wind tunnel tests. The benefits are obvious for a continuously evolving weapon system such as JDAM.

Members of the JDAM family employ satellite-based GPS for navigation to achieve very high accuracy of delivery to targets in all weather conditions, day or night. Traditional autopilot design for such munitions depends strongly on the availability of wind tunnel data to characterize the munition's aerodynamic forces and movements.

Through on-line learning, the adaptive autopilot compensates in flight for uncertainty in aerodynamic data and can therefore greatly relieve dependence on wind tunnel data in the autopilot design process. The AAA replaces JDAM's existing gain-scheduled autopilot software with no other changes to the airframe hardware or software.



Directorate engineers dropped the first guided test vehicle (GTV1) from an altitude of 25,000 ft and used the JDAM Inertial Navigation System/GPS guidance with the AAA to successfully impact a surveyed target at Eglin's test range B-70. The weapon, dropped from an altitude of 35,000 ft, followed a preprogrammed controlled flight profile designed to exercise the autopilot stability and performance.

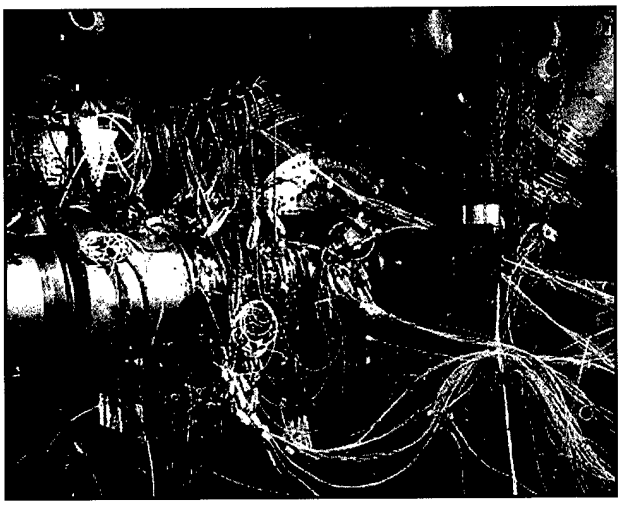
Based on telemetry data obtained during the test, the autopilot performed as intended. In fact, the AAA allowed the weapon to achieve controlled flight at negative angles-of-attack; this was a first for the MK-84 JDAM.

Based on initial telemetry data obtained during the test, the autopilot performed as intended. Impact site video showed that the weapon hit the base of the target, a surveyed concrete marker.

Splittered Fan Produces Highest Pressure Ratio in a Single Stage

The Propulsion Directorate successfully tested an advanced splittered fan in the directorate's Compressor Research Facility. This fan demonstrated a higher pressure ratio in a single stage than any other single-stage fan built to date. This performance will enable reduced costs, weight, and number of parts for operational weapon systems.

Honeywell Engine Systems & Services designed the fan for their Integrated High Performance Turbine Engine Technology (IHPTET) XTL57 Joint Expendable Turbine Engine Concept (JETEC) demonstrator. This new design employs 1/2-cord splitter blades alternating between full cord blades. The fan demonstrated its design pressure and flow rate at 100%, while achieving peak efficiency at 70 to 80% of the design speed. For this test, the inlet flow was distorted at two levels to simulate maneuvering. The fan maintained its high performance during these distortion tests, which in turn predicts a good tolerance for high angle-of-attack maneuvers.



The IHPTET program is an ongoing national effort to double US military aircraft propulsion capability. The IHPTET team coordinates the gas turbine engine research and development activities of the Army, Navy, Air Force, National Aeronautics and Space Administration, Defense Advanced Research Projects Agency, and six US turbine engine manufacturers.

Honeywell Engine Systems specifically designed this fan for their IHPTET XTL57 JETEC demonstrator. Researchers developed the JETEC technologies in this demonstrator for a limited life turbine engine. For this program, a cost-sharing arrangement between government and industry utilized Dual-Use Science and Technology program funds.

Expendable/limited life engines are one of three classes of engines under the IHPTET technology development program. Typical applications for such engines are cruise missiles and unmanned air vehicles. Compared to current turbine engines, vehicles equipped with a splittered fan engine will demonstrate increased performance, increased range, lower weight, and reduced cost.

Propulsion Directorate Scientists Demonstrate Significant Advance in Superconductive Materials

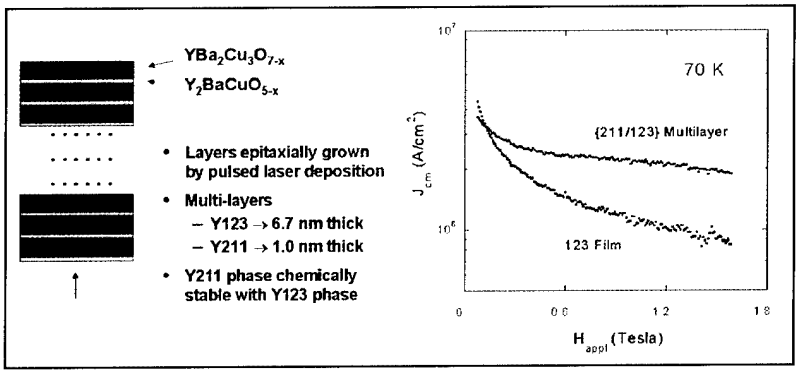
Scientists from the Propulsion Directorate produced and demonstrated a flux pinning mechanism for superconducting material that will bring completely new classes of high-power generators and electrically driven weapon systems closer to reality.

The directorate's Superconductivity Group developed a new method for flux pinning superconductive yttrium-barium-copper-oxide (YBaCuO)-coated substrates. By laser depositing alternating layers of superconducting and non-superconducting material, the team dramatically improved the current carrying capability of the material in higher magnetic fields.

This increase in flux pinning doubled the material's critical current density at 70° Kelvin (K) 1 Tesla, over that of a normally prepared sample. In an initial sample prepared by the group, the critical current density was even more than double at applied fields greater than 1 Tesla, 70° K.

Flux pinning is an important phenomenon in superconductivity. Flux pinning traps or "pins" magnetic lines of force, called fluxons, inside superconducting material.

Superconductors can carry a bulk current density only if the pinning maintains the macroscopic fluxon density gradient. Increasing the magnetic field, or temperature, weakens the potential wells of the pinning sites.



If the fluxon density gradient is lost, the superconducting material loses its superconducting properties. Flux pinning depends on the actual crystalline structure of the superconducting material and has an impact on the amount of current a superconductor can handle. Higher current density results when magnetic lines of flux are effectively "pinned" within the superconducting material.

In the directorate's approach, the incorporated non-superconducting layers are only about a nanometer in width. A key element is the use of non-superconducting interlayer compounds that are not chemically reactive with the high-temperature superconducting (HTS) material.

This is a critical characteristic as many compounds diffuse and react with the HTS during the high-temperature processing when using thin layers. The scientists used pulsed laser deposition to make alternating layers of $YBa_2Cu_3O_{7-x}$ superconducting and Y_2BaCuO_{5-x} non-superconducting material. Scientists can also use this process in other thin film deposition or coating techniques and with other HTS materials.

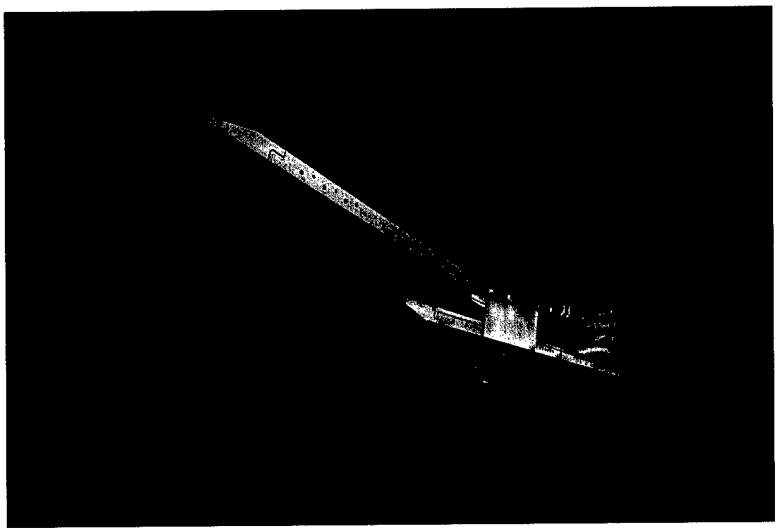
HyTech Program One Step Closer to Integration of Scramjet Propulsion

Researchers from the Propulsion Directorate and their commercial partners crossed yet another bridge in the development of a hydrocarbon-fueled, supersonic combustion ramjet (scramjet) engine. This type of propulsion will allow longer range and dramatically decreased reaction time for weapons used against high-value targets at long standoff ranges.

The directorate successfully completed the first-ever hydrocarbon fuel-cooled combustion initiator (pilot) demonstration under its Hypersonic Technology (HyTech) program. Engineers from United Technologies Research Center, a subsidiary of Pratt & Whitney of West Palm Beach, Florida, integrated a hydrocarbon fuel-cooled, flight-like pilot system into the United States Air Force-owned scramjet combustor.

Although developed for one-time use, the scramjet operated through seven combustion cycles. The tests met all the thermal design requirements and test objectives. Specifically, the engine never exceeded material temperature and structural limits. Posttest results suggest that no fuel coking occurred during the tests, another positive sign for scramjet operability.

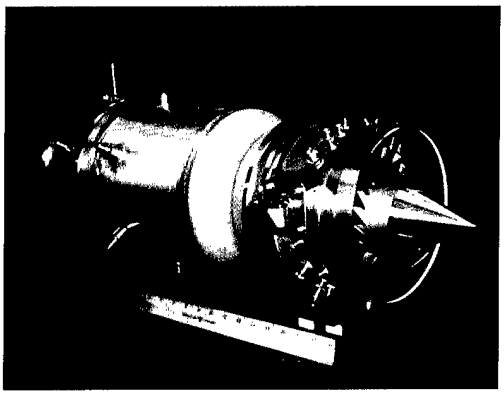
The HyTech program is the latest in a long series of Air Force efforts to prove the viability and utility of the supersonic combustion ramjet engine. Current plans call for the directorate to fly the hydrocarbon scramjet engine technology on the X-43C demonstrator vehicle.



The X-43C program is a joint National Aeronautics and Space Administration and Air Force program that will fly the HySET engine on a flight test vehicle similar to and larger than the Hyper-X vehicle (X-43A). Directorate engineers continue to investigate high-speed propulsion technologies with widespread applicability.

By maturing scramjet propulsion, researchers will also provide a key component to a new breed of propulsion known as the combined cycle engine. These engines, made from some combination of turbine, ramjet, scramjet, and rocket engines, use each of the different cycles to the fullest advantage of their respective efficiencies. Such combined-cycle engines will enable a family of vehicles, which includes global range, high-speed aircraft and "spaceplane"-type vehicles with cost-effective, on-demand access to space for future systems.

New Generation Advanced Engine Successfully Tested



Williams International's XTL86/2 engine, a small turbojet developed under the Integrated High Performance Turbine Engine Technology (IHPTET) program, demonstrated dramatically improved performance over conventional missile engine designs. This engine is capable of providing the thrust, without afterburner, necessary to reach the Mach 3+ speeds required for future missile operations.

Approach Williams International recently tested a new generation advanced engine. This small turbojet engine will provide support to the Propulsion Directorate's and Department of Defense's (DoD) high-speed air vehicle programs, as well as the National Aeronautics and Space Administration's (NASA) low-cost access-to-space plans, at Williams International's Walled Lake, Michigan facility.

Background The cooperative DoD/NASA/industry IHPTET program develops advanced material and component technologies for future Mach 3+ missile and air vehicle applications. The IHPTET program also advances those technologies to double the performance of all classes of military turbine engines.

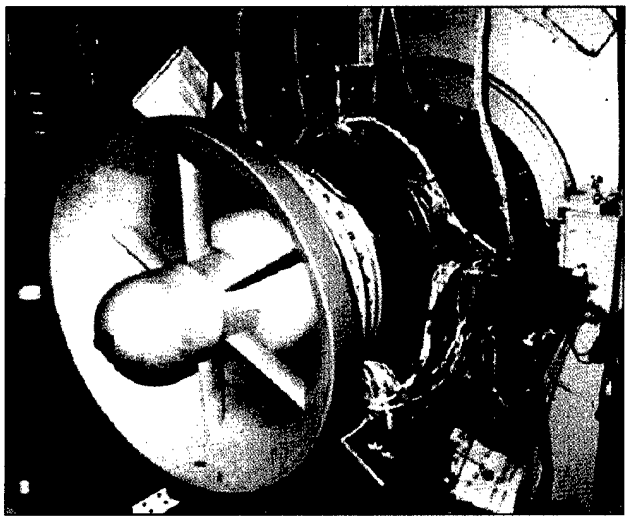
IHPTET's Phase II goals call for an aggressive 70% increase in specific thrust over its baseline turbine engine and the capability to run turbine temperatures 900°F hotter than normal without extracting compressor air to cool the hot section of the engine. The XTL86/2 engine recently achieved both of these goals in a single demonstration run.

IHPTET also has an aggressive goal for engine cost reduction. Engine manufacturers must design demonstrator engines, such as the XTL86/2, to sell for 45% less than baseline turbine engines. The XTL86/2 met that goal with its design simplicity, minimal part count, and use of advanced ceramic composite hot section materials. The turbine nozzle, turbine rotor, and exhaust nozzle assembly are all made from new composite materials that can operate at very high temperatures without incurring the complexity, performance, and cost penalties associated with air cooling.

In-House Research Reveals Source of Performance Loss in Transonic Compressors

The Propulsion Directorate's Compressor Research Group found that blade-row interactions have a significant impact on the performance of a transonic compressor stage. After extensive research utilizing experimental testing and numerical simulation, directorate engineers found a previously unidentified loss-producing mechanism, which was a result of close spacing between a stator blade-row and a transonic rotor blade-row. Loss refers to any fluid-flow feature that reduces the efficiency and pressure rise capability of a compressor.

At the Compressor Aero Research Lab (CARL), directorate engineers documented how mass flow rate, pressure ratio, and efficiency all changed significantly as they reduced blade-row axial spacing from "far to close." Directorate engineers found two separate outcomes when they simulated interaction between a stator blade-row and a rotor blade-row at close and far spacing.



At close spacing, the stator trailing edge chops the rotor bow shock, forming a pressure wave on the upper surface of the stator, which turns nearly normal to flow and propagates upstream. The flow is supersonic relative to this pressure wave, producing additional loss.

Far spacing produces no additional loss due to the rotor bow shock degenerating into a bow wave before interacting with the stator trailing edge and, therefore, no significant pressure wave forms on the stator upper surface. These results demonstrate the importance of considering unsteady blade-row interactions when designing transonic fans and compressors due to the significant amount of loss produced.

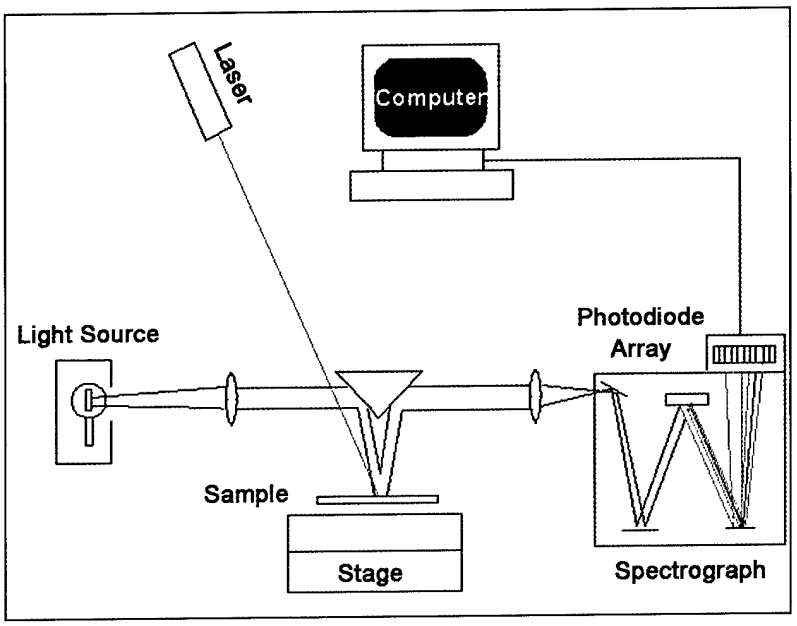
The research performed at CARL is part of an in-house project named High Impact Technology. Some technical challenges make it difficult to meet Integrated High Performance Turbine Engine Technology (IHPTET) and Versatile Affordable Advanced Turbine Engines (VAATE) objectives of increased stage loading and efficiency. However, after much experimental and computational analysis of blade-row interactions, researchers better understood the losses, which proved to be a breakthrough analysis.

The IHPTET program is an ongoing national effort to double United States (US) military aircraft propulsion capability. The new VAATE program will develop versatile advanced gas turbine engines that are more affordable, where affordability is defined by a capability-to-cost ratio. These programs coordinate the gas turbine engine research and development activities of the Army, Navy, Air Force, National Aeronautics and Space Administration, Defense Advanced Research Projects Agency, and six US turbine engine manufacturers. VAATE builds on this team collaboration by adding the Department of Energy and US major weapon system manufacturers.

Measuring Device for Thin Semiconductor Film Deposited on Semiconductor Wafers

Scientists can now accurately measure the thickness, composition, and doping of epitaxial layers by using reflected white light off the surface of a semiconductor wafer. Epitaxy refers to the growing of crystals of one mineral on the face of another mineral so both substrates have the same structural orientation. This nondestructive measurement system will permit rapid development of new device structures at lower cost and with increased yield, while providing a quality assurance tool for semiconductor device manufacturers.

Scientists at the Sensors Directorate developed and patented an innovative technique that measures thickness, composition, and doping of semiconductor epitaxial layers. Users accomplish this by measuring and fitting the spectroreflectance in wavelength range where there is significant variation of the refractive index (near the semiconductor band gap). Manufacturers formerly spent hours taking measurements nondestructively, but now spend just seconds.



Manufacturers have used spectroreflectance since the 1960s to measure the thickness of semiconductor layers. While this method is very successful in measuring thickness, scientists must use another technique to measure material composition.

Extracting composition and thickness using spectroreflectance is difficult due to a coupling problem. In spectroreflectance, the optical thickness, which is proportional to n x d where n is the composition-dependent refractive index and d is the actual layer thickness, is actually measured.

The same optical thickness can result by increasing composition and decreasing thickness or vice versa—a condition known as coupling. The coupling problem occurs in the wavelength range in which users measure the reflectance because the refractive index is substantially constant as a function of wavelength. As a result, manufacturers analyzed the composition using other measurement techniques as the traditional approach to decouple the composition and thickness.

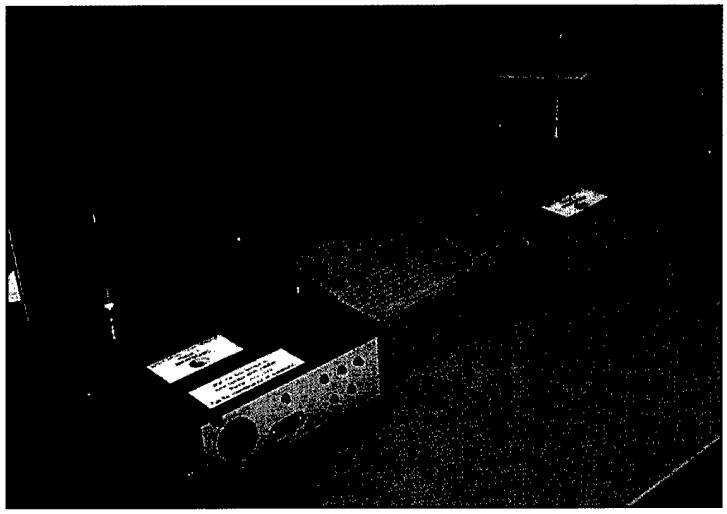
Directorate researchers overcame this coupling problem by measuring the spectroreflectance in a wavelength range where there are significant variations of the refractive index, near one of the semiconductor critical points. They obtained good agreement between the composition determined by spectroreflectance and other common measuring techniques. This technique received a US patent.

Tornado Warning System Tone Alert Receiver

Researchers from the Sensors Directorate designed and fabricated an in-house, electronic radio frequency receiver that responds to Wright-Patterson Air Force Base's (AFB's) tornado alert broadcast, giving personnel added time to reach an emergency shelter. Directorate personnel in several different locations on base can now receive tornado warnings in a timely manner and seek safety in designated shelters.

Directorate researchers developed a Warning System Tone Alert Receiver (TAR) that reduces emergency notification time for directorate personnel. One of the more unique features that differentiates the Warning System TAR from similar TARs is the integrated, flashing red light and buzzer, which gives visual and audible cues that the receiver has detected a tornado alert broadcast.

The Wright-Patterson AFB 88th Air Base Wing Command Post uses radio signals to activate sirens during tornado warnings or other severe weather conditions. Previous weather alerts highlighted a significant deficiency in the base notification system to alert the directorate within a reasonable time after initiating the weather warning.



The Wright-Patterson AFB Command Post used the Simultaneous Alert System telephone network for previous notifications. Generally, this occurred 8-10 minutes after activating the base sirens. The sighting of a storm within the proximity of Wright-Patterson AFB, coupled with the time delay of notification and personnel movement to the shelters, made it apparent that a disaster could occur prior to directorate personnel reaching their shelter.

Directorate personnel developed two prototype Siren Detection Sensor (SDS) receivers to recognize coded waveforms transmitted on a very high frequency base disaster channel. The SDS receivers detect the base siren tones inside the directorate's building and alert personnel of severe weather in the area of Wright-Patterson AFB. Directorate researchers successfully demonstrated the systems during the base weather exercise "STRONGWIND 01."

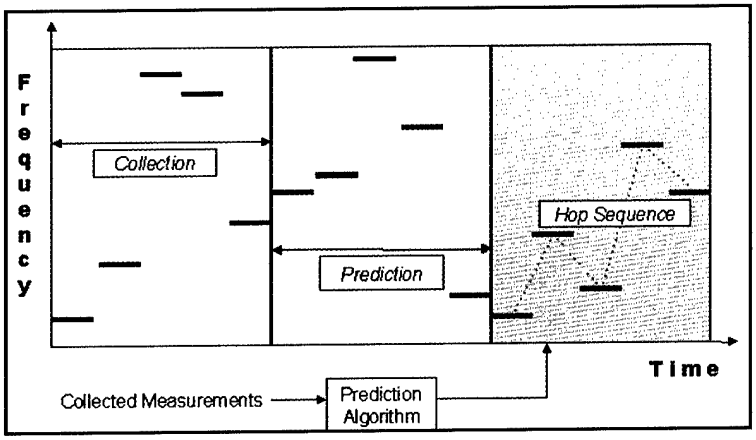
Sensors Directorate Develops Countermeasures Against Frequency Agile Signals

The Sensors Directorate's successful software implementation of the hop prediction system provides a valuable baseline to the hardware implementation of the frequency agile prediction system. The time-difference-of-arrival technique will provide increased capability, particularly against fast frequency hoppers, at lower cost and complexity of hardware since it monitors only one frequency among the many the system can hop over.

In a joint effort with Robert Gold Communication Systems (RGCS), directorate scientists are developing countermeasures against frequency agile signals. Engineers use frequency agile signals to provide resistance to jamming, reduce the likelihood against detection, and offer protection from enemy missiles.

RGCS engineers developed software that uses the time-of-arrival of a few transmissions to determine the hopping pattern of frequency agile signals. As hop rates and standoff distances increase, propagation distances and processing time make it impossible to use "follower" jamming techniques to combat frequency agile signals. Scientists can overcome this deficiency by using times-of-arrival processing techniques.

While two aircraft are communicating over a relatively short range, a standoff sensor or jammer must receive the signal, process the signal, and transmit a jamming signal back to the receiver. The aircraft must complete this process before the receiver changes to another frequency in response to the frequency agility of the target transmitter. As technology continues to develop, frequency synthesizers, used in frequency hopping spread spectrum communication and radar systems, will operate at increasingly higher hop rates, and repeat-back or frequency-follower jammers will become less effective.



Since engineers developed frequency synthesizer implementations that operate at several hundred thousand hops per second and since rates in excess of one million hops per second are entirely feasible, the futility of pursing a follower jammer is clear. Tactical airborne military electronic attack and electronic protection systems have the requirement that any technique developed must operate in real time. This requirement is due to the rapidly changing nature of the battle scenario, the typically short message bursts, and the ability of the uncooperative target link to change the code-of-the-day.

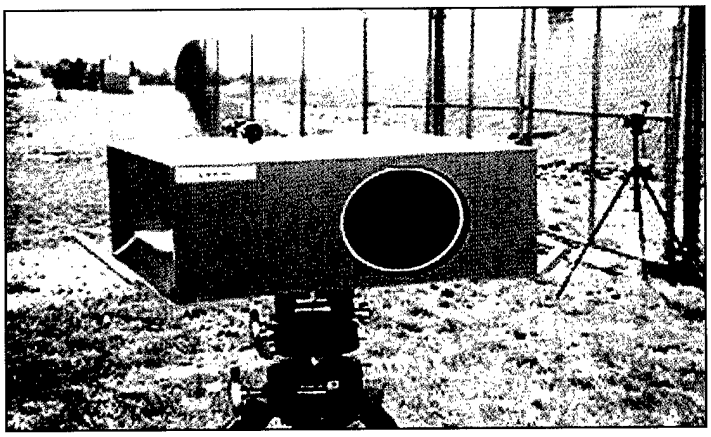
Directorate researchers studied algorithmic techniques to identify information concerning the hard-wired and logical structure of the hopper equipment used by the algorithm to exploit these weaknesses. The time-difference-of-arrival technique requires a collection time where times-of-arrival to single frequency are made. Then the algorithm goes to work, determines the sequence, achieves synchronization, and predicts where and when each successive frequency occurs.

Enhanced Compact Mid-Infrared Chemical Remote Sensing

The Sensors Directorate funded a Small Business Innovation Research Phase III project for LaSen, Inc. in Las Cruces, New Mexico, to build a compact, portable sensor capable of determining the real-time location, as well as identification and concentration levels, for a number of chemical vapors and aerosol clouds. Directorate engineers needed this system to meet the needs of possible environmental incidents, such as toxic chemical spills, or wartime/terrorist activities such as release of chemical agents.

LaSen engineers designed and fabricated a compact lightweight laser radar system that uses a solid-state laser operating in the 3-5 micron band. Engineers demonstrated the system at White Sands Missile Range and used the system to map out-gassing from an underground fuel spill. The sensor uses a technique known as Differential Absorption Ladar to detect and measure chemical clouds at ranges of up to 2 kilometers.

Directorate engineers are studying this same technology for use in a number of Air Force tactical applications such as finding military targets concealed by camouflage or foliage. Other applications include detecting chemical agent production and storage facilities as well as agent releases into the atmosphere.



Directorate engineers estimate a 25% reduction of the current costs of conducting regulatory mandated surveys on public lands and pipeline right-of-ways by installing this device on an aircraft. They are also considering using this technology as part of their Active Multi-Spectral Imaging program.

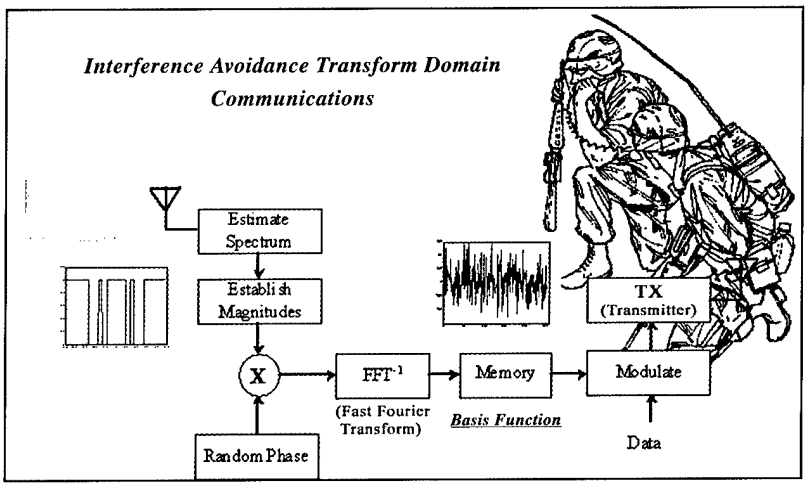
LaSen, Inc. plans to obtain certification and acceptance of this technology by natural gas companies to provide mapping and leak monitoring of their pipelines as a commercial service. Conservative estimates predict that such a service could generate >$100M annually. Other possible applications include monitoring dumpsites, searching for illegal toxic dumping, environmental compliance monitoring, and searching for leaks in underground oil and natural gas pipelines.

Transform Domain Communications System

The Transform Domain Communications system will provide the ability to transmit information accurately in a noisy environment with the presence of jamming, crosstalk, or multipath interference. The same techniques used for jamming waveforms will help prevent self-interference and electromagnetic interference effects. Transform domain techniques are potentially the most significant development in radio frequency communications technology.

Scientists at the Sensors Directorate modeled a transmitter and receiver technology that generates interference-avoiding waveforms to provide clear and accurate communications between users. Known as the Transform Domain Communications system, it uses adaptive notching to avoid spectrally crowded regions where interference may occur. The system uses no carrier modulation, but rather modulates data as a "noise like" basis function.

Historically, engineers designed waveforms in the time domain and accepted the frequency characteristics as a consequence; however, they could tailor the spectral characteristics of the waveform by selecting the operating parameters and filtering. They will design future waveforms using transform domain techniques to satisfy the requirements of spectral effectiveness, interference avoidance, and information throughput efficiency.

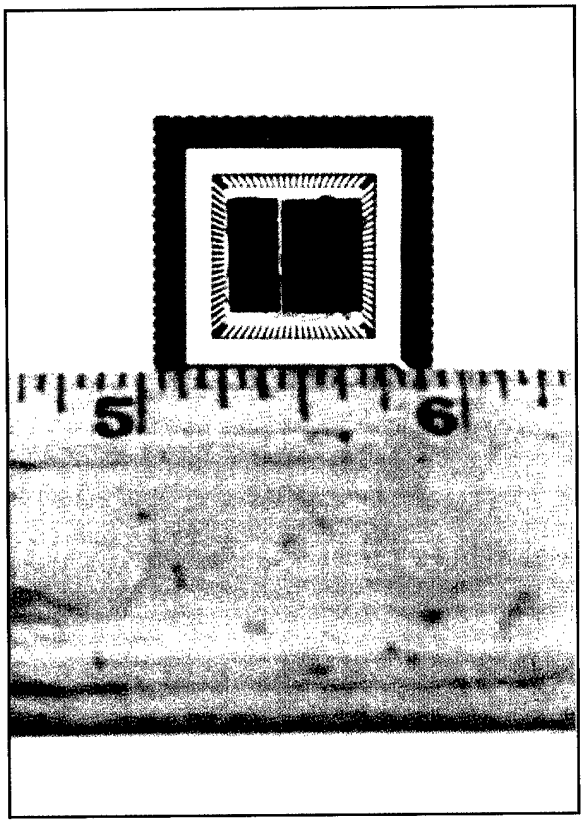


Digital signal processing advances make transform domain waveforms possible. Although many reasons exist for applying transform domain concepts, the directorate focused this research toward the analysis and development of an interference avoidance capability and the development of a jamming waveform that reduces self-interference and offers electromagnetic interference reduction.

The basic concept of a transform domain-based communications system is simple. The transmitter and receiver sample the environment and produce an estimate of the local interference. From this estimate, engineers design a waveform in the transform domain, which contains no (or very little) energy in the areas occupied by the interference.

New Phase Shifter ESA for Space-Based and Unmanned Combat Air Vehicle Sensors

Sensors Directorate scientists helped design, build, and demonstrate a new type of phase shifter via a Dual Use Science and Technology program. This new shifter gives two times the bandwidth and two times the phase shift of earlier designs, resulting in about 1 GHz of useful bandwidth centered at 9.2 GHz and 100° of phase shift (37° of scan in the E-plane).



A low-loss, low-cost, low-power, low-weight phase shifter concept, integrated into an Electronically Scanned Antenna (ESA) composed of revolutionary radiating elements, achieved the elevation scan. These phase shifters have potential application in a low-cost, flat profile, X-band, one-dimensional (1-D) ESA that is suitable for space-based and unmanned combat air vehicles. In addition to these benefits, the flat profile makes the ESA an excellent candidate for a conformal fit to the skin of the aircraft, thus mitigating the need for a radome.

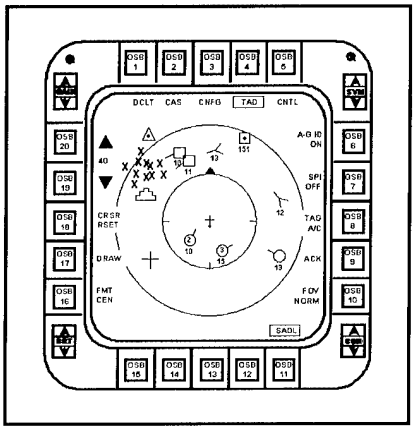
This new phase shifter is a low-cost, low-power consumption, reciprocal phase shifter capable of achieving electronic antenna scans in 1-D. Directorate scientists demonstrated the new ESA in several configurations in the laboratory including 1-D electronic scan in the E-plane using the basic configuration and 2-D electronic scan achieved by integrating an active Transmit/Receive (T/R) module like those feeding into the basic ESA.

ESAs, distinct from Mechanically Scanned Antennas, are desirable for a number of reasons including reliability and performance. However, conventional ESAs based on T/R module technology are very expensive and require complex beam steering electronic/computers and substantial prime power. Technologies that reduce the number of T/R modules and thus reduce the antenna cost, weight, and power consumption with minimal performance impact are an active area of research.

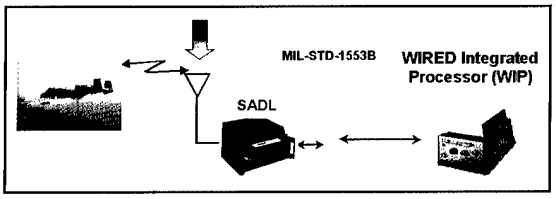
Unmanned air vehicles are substantially smaller than conventional combat and surveillance aircraft and require lighter and lower cost radar. The warfighter, however, still requires a high-performance, all-weather surveillance and targeting platform. This technology has applications to space-based radar with potential benefits of improved radar reliability via the removal of an electromechanical gimbal as well as performance enhancements via precision electronic beam scanning and low antenna manufacturing costs.

Situation Awareness Data Link Radio Provides Warfighters with a Secure Communications System

The Situation Awareness Data Link (SADL) radio system provides a secure, jam resistant air-to-air network for up to four flights of four aircraft each with automatic relaying for increased mobility and range. F-16 and A-10 aircraft use this system to provide close air and combat search and rescue mission support.



Scientists at the Sensors Directorate demonstrated the first integrated laboratory demonstration of a radio system linking of an AC-130 Gunship aircraft with close air support aircraft and ground assets. The demonstration fully integrated a "point and click" operator interface for the radio link requiring no additional aircrew members. The SADL radio is an airborne version of the Army Enhanced Position Location Reporting System radio that provides a wireless data communications backbone for the Army's tactical Internet. The major benefit of the SADL is that the two systems operate together, providing warfighters with a secure communications system.



The AC-130 SADL interface uses open systems architecture techniques. The software consists of a SADL interface module using 3,600 lines of code and a SADL display module using 5,000 lines of code.

The combined SADL software interface and display executable module is 5,870 Kbytes in size and uses 6 Mbytes on the integrated Wind Tunnel Integrated Real-Time Information in the Cockpit/Real-Time Information out of the Cockpit Experiments and Demonstrations (WIRED) processor-embedded PowerPC. Directorate scientists performed a hardware-in-the-loop demonstration where the WIRED integrated processor system interfaced with a SADL radio system, simulating one aircraft.

Directorate scientists then used a workstation to connect the second SADL radio system, simulating a two-ship formation. Next, the scientists performed a close-air-support mission with ground friendlies identified on the SADL tactical awareness display along with other aircraft and targets.

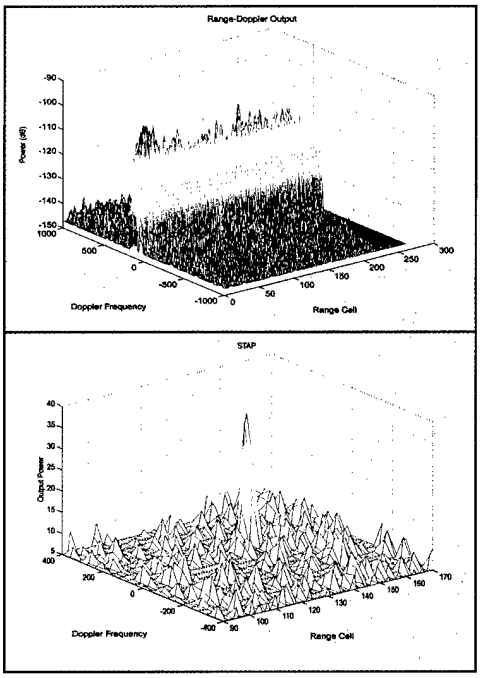
The AC-130 aircraft provided forward air controller functions and transferred A-10 targets digitally by the SADL radio to the simulated A-10 aircraft. In addition, the AC-130 aircraft demonstrated close air support nine-line message transfer.

Research Laboratory Space-Time Adaptive Processing

The Research Laboratory Space-Time Adaptive Processing (RLSTAP) Algorithm Development Tool, a radar system modeling and analysis tool, generates high-fidelity radar data for evaluation of radar system performance for advanced airborne and space-based radar platforms. RLSTAP can process and evaluate measured radar data and simulate airborne, spaceborne, or ground-based multi-channel radar data in jamming and clutter environments.

In addition, RLSTAP combines measured and simulated radar data, develops and evaluates new space-time adaptive processing algorithms, and assesses the performance of advanced radar systems and advanced signal processing technologies. This new technology allows for advanced concept exploration that realistically predicts operational performance. RLSTAP evaluates innovative concepts and proposals, providing significant risk reduction.

The Sensors Directorate's Radar Signal Processing Branch, led by Mr. Douglas Lynch and located at the Rome Research Site in Rome, New York, created RLSTAP. The extensive capability of RLSTAP is highly adaptive to new requirements and is a cost-effective modeling vehicle for many new programs. The technology transfer to Operational Systems is user friendly and has multiple modes. RLSTAP highlights design deficiencies prior to building hardware, thus reducing design and development time. It allows users to process experimental data and diagnose unanticipated results.



Among the many applications, directorate engineers can use RLSTAP to evaluate proposed systems such as Joint Surveillance and Target Attack Reconnaissance System, Airborne Warning and Control System, F-22, Joint Strike Fighter, Unmanned Air Vehicles, Space Based Radar (SBR), Discoverer II, and the FOPEN (FOliage PENetration) Radar Electronic Support Measures Synergy for Targeting System. In addition, Defense Advanced Research Projects Agency/ Special Projects Office will use it to model various jamming techniques and jammer mitigation algorithms.

Created in conjunction with CAESoft Corporation of Garland, Texas, RLSTAP interfaces well with other software including MATLAB (a math software) and CAESoft Phased Array Antenna Simulation. It has the capability to import antenna patterns generated by third party software.

Prior to the development of the RLSTAP Algorithm Development Tool, the testing process was expensive and labor-intensive. Technology was not available to test advanced signal processing techniques without the construction of hardware systems flown on test aircraft. The cost of flight testing could exceed $10,000 per hour.

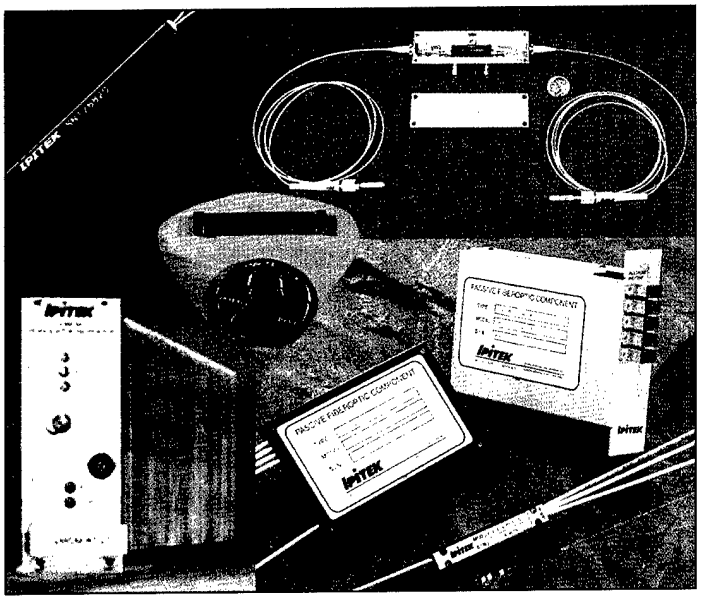
RLSTAP integrates and extends the capabilities of previous and ongoing programs. Broad application to both government and private sectors was demonstrated to include Airborne Moving Target Indication, Ground Moving Target Indication, SBR, and Synthetic Aperture Radar Systems; Multichannel and Multiple Coherent Processing Interval; Tracking and Bistatics; Advanced Jammers and Electronic Counter-Countermeasures; Site Specific Clutter; and Aircraft Interaction Effects.

RLSTAP provides modularity; high fidelity; multiple platform types; the capability to use look-up tables to import data; active and passive system analysis; polarization; and wide bandwith, using monostatic and bistatic analysis, capable of adapting to user needs.

Low V_π Polymer Modulator Research for Analog RF Systems

Sensors Directorate personnel managed a Small Business Innovation Research (SBIR) Phase II project that meets the Air Force requirement for fiber optic radio frequency (RF) links that provide all the benefits of fiber optics without signal degradation or conversion losses.

IPICON, formerly known as TACAN, successfully demonstrated that polymer devices and modulation techniques that take advantage of the properties of newly developed polymer materials enable loss-less RF links over specific bandwidths. IPICON engineers fabricated polymer modulators that decrease insertion losses, and reduce the half-wave voltage to less than 1 volt.

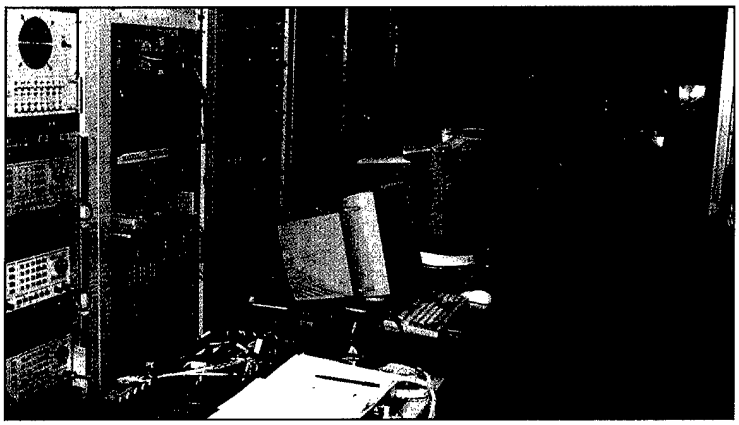


Based on their SBIR research in optical components, IPICON engineers developed and produced a number of devices currently in operational use for the Secure Military System. IPICON engineers also developed components incorporated into equipment items, supporting the television industry. Television studios, remote locations, and cable television distribution networks use IPICON equipment worldwide.

TACAN received SBIR's Tibbitt Award for Small Business Achievement and international acclaim for the production of the lowest operational optical modulator with their sub 1-volt devices. Recently, TACAN changed its name to IPICON, a prime developer of polymer modulators.

Sensors Directorate Successfully Evaluates JASSM Anti-Jam GPS Technology

The Sensors Directorate's Advanced Concepts Exploration Team successfully evaluated the Joint Air-to-Surface Standoff Missile (JASSM) Advanced Global Positioning System (GPS) receiver, using the Antenna WaveFront Simulator (AWS) Virtual Flight Testing (VFT) environment. Directorate engineers used this VFT analysis as a preflight predictor of their JASSM GPS anti-jam performance during a live captive carrier flight test at Holloman Air Force Base, New Mexico, as a cost and schedule reduction effort. The JASSM System Program Office also used this flight test to demonstrate the viability of VFT evaluations to assess GPS anti-jam effectiveness for missile applications—a first for the directorate.



Working with Lockheed Martin Owego and Orlando, the directorate team integrated the JASSM antenna data, missile trajectory, Holloman AFB jammer laydown, JASSM advanced GPS receiver, and ideal inertial aiding simulation with the VFT. Engineers integrated the JASSM's Missile Computer Unit and Inertial Measurement Unit simulation with the VFT configuration. The directorate then expanded the VFT simulation to include a navigation warfare scenario to thoroughly characterize the performance of the JASSM navigation system.

The directorate developed the AWS to support the evaluation of GPS anti-jam systems for aircraft applications. They recently reconfigured the AWS to model radio frequency ionospheric scintillation effects on GPS receiver performance.

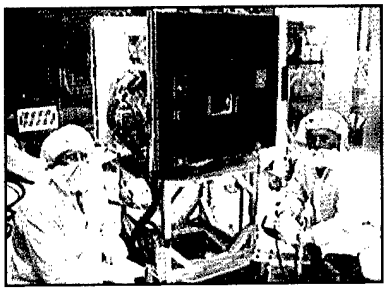
This unique hardware-in-the-loop has now evolved into a VFT capability to meet the ever-increasing challenges associated with GPS modernization and anti-jam research. Directorate engineers interfaced the GPS Interference and Navigation Tool, an Air Force Standard Analysis Toolkit, with the AWS to provide a VFT environment that generates resultant measures of effectiveness.

This capability, coupled with additional modeling and simulation features, such as satellite dynamics, Inertial Navigation System aiding, high-power jammers, and realistic antenna modeling, provides a unique simulation test bed to thoroughly characterize a wide variety of GPS anti-jam technologies. In the JASSM in-house project, this capability clearly demonstrated the viability of using the VFT environment for long-range missile applications.

MightySat II Completes One-Year On-Orbit Mission

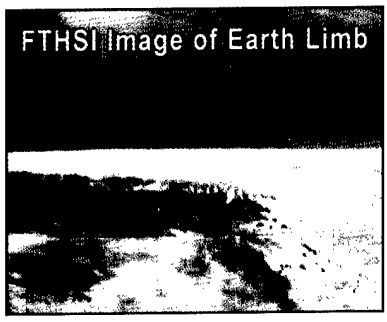
The Space Vehicles Directorate's highly capable MightySat II satellite, equipped with a Fourier Transform Hyperspectral Imager (FTHSI), completed its 1-year on-orbit mission to prove 10 advanced technologies in space.

The joint Department of Defense Space Test Program and the directorate's MightySat II satellite completed its 12-month mission to boldly demonstrate cutting-edge space technologies following the satellite's Minotaur 2 launch and orbital insertion. While experiencing a mere handful of spacecraft anomalies during its 1-year mission, MightySat II continues to operate its experimental payloads.



In less than 2 weeks time, the primary experiment, FTHSI, collected, downloaded, and processed 163 hyperspectral images, while the Shape Memory Alloy Thermal Tailoring experiment cycled over 1,500 times, and the satellite traveled 152 million miles in its 550-kilometer, sun-synchronous orbit. FTHSI provided the first hyperspectral image from space, the first space-based hyperspectral image of the earth limb, and several moon shots.

MightySat II continued its mission, following deployment of ½ lb-each PicoSats (miniature satellites). In addition to the satellite's nearly flawless on-orbit performance, the directorate awarded the MightySat II Team its Annual Team Award, while AFRL awarded the MightySat II Team the AFRL Commander's Cup Team Award.

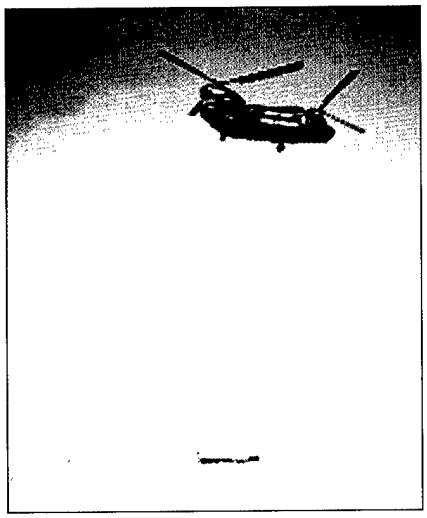


Two classes of MightySat II payloads exist—experimental bus components and stand-alone experiments. Experimental bus components are proven hardware and include a solar array concentrator, Naval Research Laboratory miniature space ground link system transponder, multi-functional composite bus structure, solar array flexible interconnect, and solar array substrate.

Stand-alone experiment payloads aboard MightySat II include FTHSI, quad-C40 processor, Shape Memory Alloy Thermal Tailoring experiment, the Defense Advanced Research Projects Agency/The Aerospace Corporation's PicoSats, and Starfire Optical Range optical reflectors.

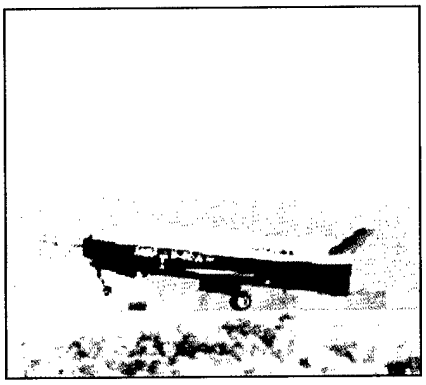
X-40A SMV Atmospheric Test Vehicle

Space Vehicles Directorate researchers released the X-40A from a helicopter at 10,000-15,000 feet above ground level to gather subsonic aerodynamic data for a future space maneuver vehicle (SMV). The directorate loaned the X-40A to the National Aeronautics and Space Administration (NASA) for use in the $172.9M cooperative Air Force/NASA/Boeing X-37 program. X-40A and X-37 both use an outer mold line derived from Boeing's Refly SMV design.



NASA and Boeing, with Space and Missile Systems Center and Space Vehicles Directorate support, conducted seven successful flight tests of the directorate's X-40A SMV. The SMV can remain on-orbit for up to one year and has high on-orbit maneuverability.

The X-40A first flew in August 1998 at Holloman AFB, New Mexico, as part of an Air Force/Boeing $12M cooperative effort to reduce the risk of autonomous approach and landing for the SMV concept. The X-40A is completely autonomous and uses Inertial Navigation System/Global Positioning System navigation, combined with a radar altimeter for precision approach and landing.

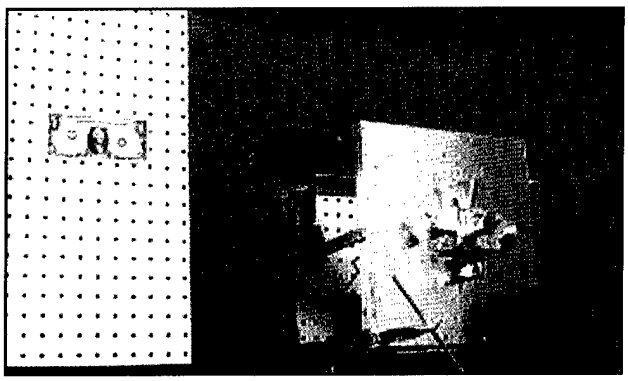


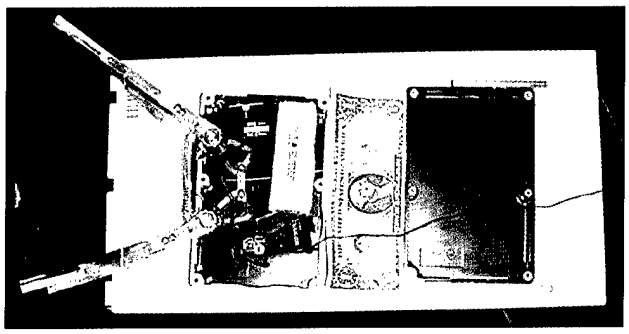
The SMV, a concept for a completely reusable satellite bus and upper stage, is part of the Military Spaceplane System reusable spacelift and operations architecture. Researchers envision SMV to be launched on an expendable or reusable launch vehicle, to perform an on-orbit mission, and then reenter the earth's atmosphere for a runway landing.

Space Countermeasures Hands-On Program Designs Docking Nanosatellite in 6 Weeks

Tasked to prove the feasibility of on-orbit satellite servicing using only off-the-shelf parts, a Space Vehicles Directorate countermeasures hands-on program team set about designing its own satellite completely from scratch, using only government surplus and hobby shop materials.

A four-person team, with no prior satellite design experience, developed a satellite that could gently dock with an on-orbit vehicle and transfer a small payload to it. No commercially available satellite possessed all the capabilities required, so the team began with a 1-cubic-foot frame and attached only the absolute minimum systems necessary for the mission.





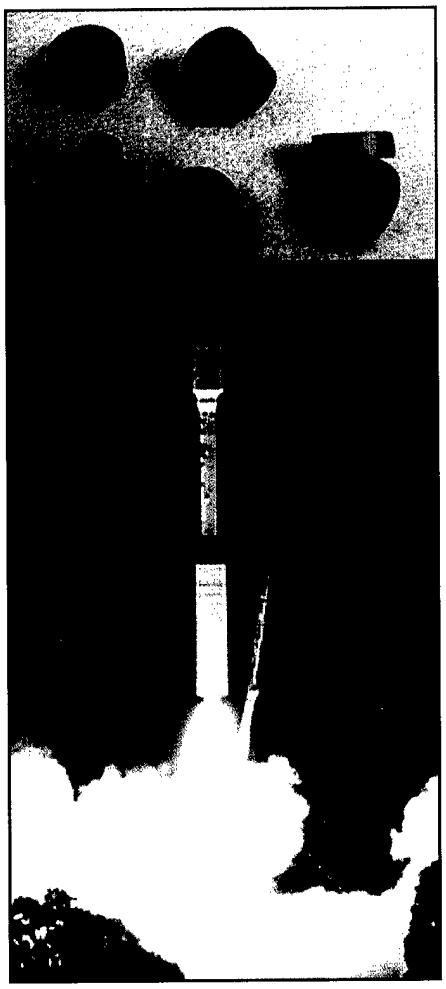
A simple video camera would provide attitude reference and visual docking capability. A standard remote-controlled airplane transmitter used by hobbyists would control the camera, thrusters, and the payload transfer. The only modifications would include an ultra high frequency booster to uplink the control commands and an S-band downlink to convey the video signals to the ground pilot.

Mission power requirements were kept so low that one battery powered all the systems, eliminating the need for solar cells. The team could start up old computer hard drives to provide attitude stabilization for the short period required. Complete system costs, including the satellite and all its systems, payload, and ground stations, could be less than $100,000. The team briefed the concept to the Air Force Scientific Advisory Board, who was highly impressed with the accomplishments and ingenuity of this *ad hoc* team of amateurs.

All on-orbit satellites eventually lose their mission capability due to expenditure of maneuver fuel or system failures. This mission helps to demonstrate that it may be feasible to dramatically extend a satellite's life span by providing on-orbit servicing. The potential savings in satellite replacement costs can reach billions of dollars in just a few years.

Avionics Isolation for Launch Vehicles

The Space Vehicles Directorate and CSA Engineering developed a system to isolate launch vehicle avionics while simultaneously providing a thermally conductive path to offload heat. The system recently flew on Taurus 6.



CSA Engineering, under the direction of directorate engineers, developed avionics isolators composed of filled viscoelastic compounds to meet the isolation and thermal conductivity requirements of Orbital Sciences Corporation for their fleet of launch vehicles. The isolators recently flew on the Taurus launch vehicle carrying a high-resolution imaging satellite [Orbview 4].

Launch vehicle avionics often require isolation from launch vibration loads to prevent damage during operation and a thermally conductive interface to offload the large amounts of heat they generate. Furthermore, launch vehicle avionics must perform these tasks over the large temperature range experienced by a launch vehicle during ascent. CSA Engineering developed an isolation component that performs both of these tasks in a single unit.

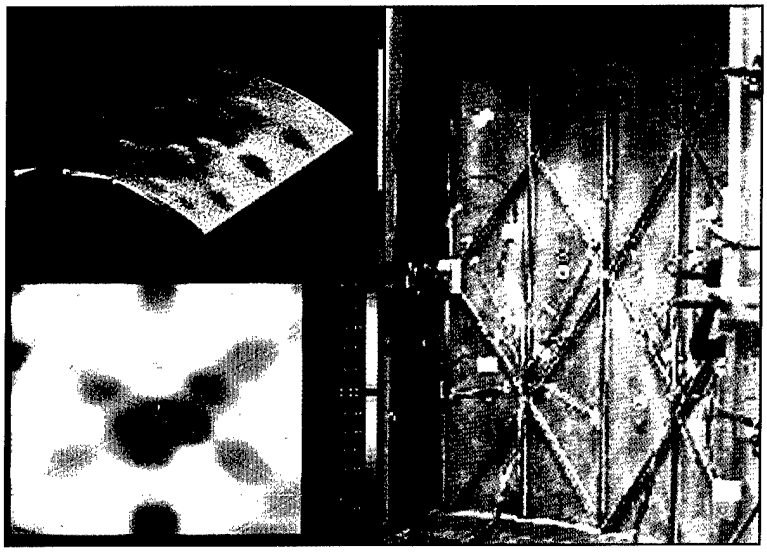
CSA Engineering is the prime contractor on the effort while Orbital Sciences Corporation is a subcontractor. CSA engineers size the isolators for interchange with existing, poorly conductive isolators. A new material provides better thermal conductivity, better vibration isolation, and less temperature sensitivity than conventional viscoelastics.

Experimental Testing of Advanced Grid-Stiffened Structures

Space Vehicles Directorate engineers designed, fabricated, and tested panels using advanced grid-stiffened (AGS) composite structures technology. The panels exceeded the predicted failure load by over 50%, demonstrating the robustness of this design.

Engineers from the directorate and Boeing Phantom Works designed and tested a series of AGS composite panels using a manufacturing technique developed and patented by the directorate. Directorate engineers conducted tests to provide design verification for a payload fairing for the Orbital Suborbital Program Space Launch Vehicle, nicknamed Minotaur, developed by the directorate for the Space and Missile Systems Center's Detachment 12.

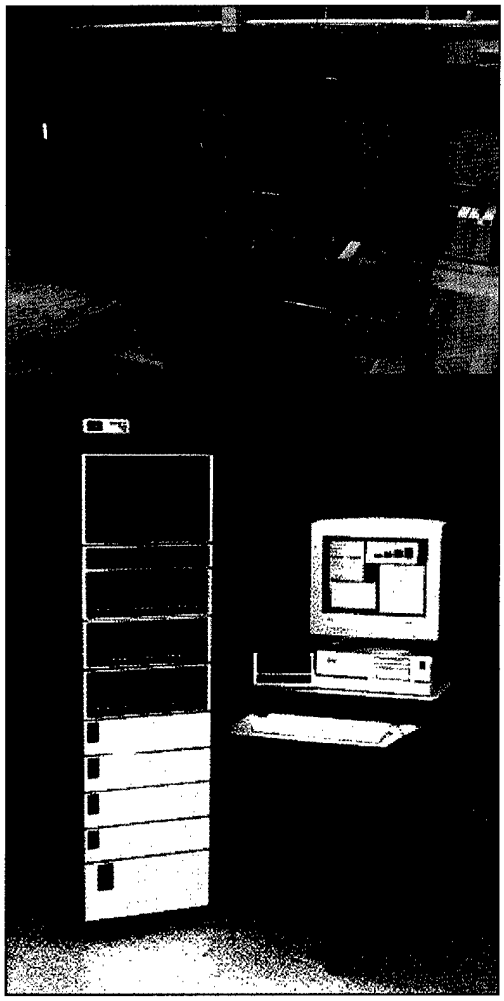
The new fairing will double the existing volume capability of this launch vehicle with only a negligible weight penalty. The test panels included a baseline grid panel, a panel with window cutouts, and a panel with a simulated separation joint.



The cost of manufacturing composite structures continues to be a driving factor behind the cost of new space systems. The manufacturing method for the directorate's AGS structures takes advantage of the automated fiber placement process to help reduce the cost of these types of structures. The directorate's cost studies predict at least a 20% reduction in the manufacturing cost of AGS structures compared to honeycomb sandwich structures. Thus, this new manufacturing process is very attractive for aerospace structures such as payload fairings, fuel tanks, and fuselage components.

Flight Qualification Test Facility

Space Vehicles Directorate engineers developed a facility to perform large-scale static and fatigue testing on virtually any aerospace structure. Directorate engineers will use this facility to flight qualify new structural systems developed by the directorate such as launch vehicle payload fairings, payload adapters, and satellite structures.



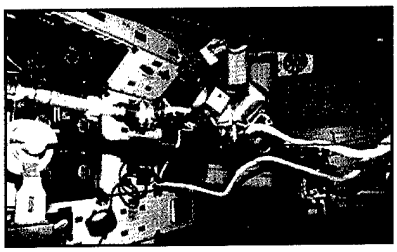
Engineers from the directorate, CSA Engineering, Dynacs, Inc., and TRW, through a partnership with the Space Test Program, integrated a multi-channel load control and data acquisition system and developed a modular test frame. The servo-hydraulic load control system simultaneously controls up to 20 hydraulic actuators at frequencies exceeding 35 Hertz, while recording up to 256 channels of transducer data.

Innovative designs in aerospace structures are becoming more complex in geometry and material selection. Driven by the desire to achieve lightweight, more efficient spacecraft components, the design and analysis of these structures continue to become increasingly sophisticated.

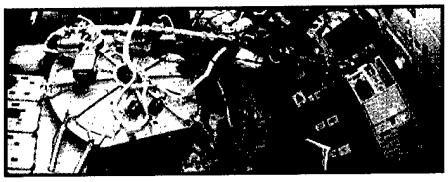
Design engineers demand increased material performance and multi-functional material capabilities. As a result, proof testing these structural components remains the only reliable technique to guarantee they are flight-ready. The directorate's Flight Qualification Test Facility allows the development and transition of Air Force-conceived spacecraft component technologies into operational systems.

Middeck Active Control Experiment Reflight Program

Middeck Active Control Experiment (MACE II) reflight program research demonstrated and validated adaptive structural control in space. This research will allow future spacecraft designers to develop lighter, more flexible spacecraft structures while meeting ever-increasing performance requirements. Adaptive structural control can autonomously create its own control algorithms and greatly decreases modeling and control system development costs. In addition, the adaptive controls approach greatly decreases assembly, integration, and test costs.



The National Aeronautics and Space Administration (NASA) selected MACE II as the first active science experiment aboard the International Space Station (ISS). MACE II returned to earth after nearly a year of successful operations on-orbit. The Space Vehicles Directorate-led science teams demonstrated and validated autonomous, adaptive structural control algorithms to control flexible structures without the need of extensive modeling and testing prior to use.



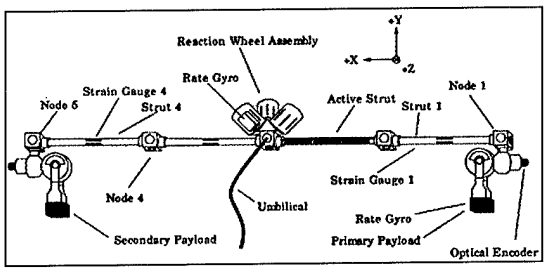
These algorithms have the capability to characterize the system dynamics, using solely the on-board sensors and actuators, and then autonomously create effective structural control systems to minimize pointing errors in the presence of onboard disturbances. In addition, these adaptive control algorithms demonstrated recovery from "failed" actuators.

As an experiment, Astronaut Susan Helms (Colonel, US Air Force) caused the actuators to fail by zeroing out their response. The adaptive controllers sensed this failure and reconfigured the control system to maintain performance. Col Helms performed over 100 protocols, or experiments, for MACE II during her stay on ISS.

The directorate wishes to acknowledge the outstanding efforts of the Department of Defense (DoD) Space Test Program (STP) managed by Space and Missile Systems Center. STP provides space flight for qualified DoD-sponsored experiments at no charge to the experimenter via the DoD Space Experiments Review Board.

The directorate leveraged existing flight hardware to create the MACE II program. NASA Langley Research Center and the Massachusetts Institute of Technology (MIT), together with a Small Business Innovation Research Phase II contract, a Cooperative Research and Development Agreement, and two educational Partnership Agreements, developed the existing flight hardware.

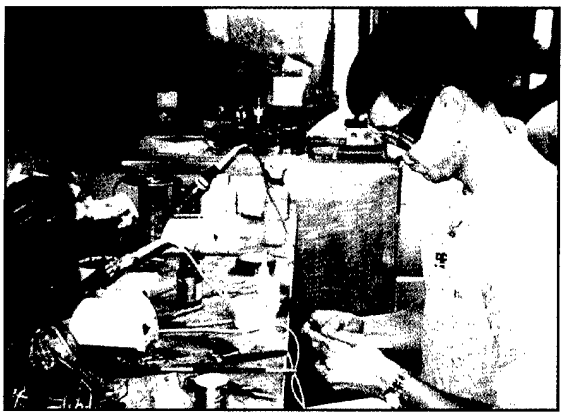
The MACE II program had two separate science teams developing structural control algorithms to demonstrate vibration suppression and precision pointing of flexible structures. The directorate-led science team includes Planning Systems (Melbourne, Florida), Payload Systems (Cambridge, Massachusetts), the University of Michigan, Virginia Tech, and Sheet Dynamics, Ltd. (Cincinnati, Ohio). The MIT-led team includes MIT, Mide Technology (Cambridge, Massachusetts), Lockheed Martin, and NASA Langley Research Center.



Space Scholars Program

The Space Scholars program invites promising undergraduate and graduate science and engineering students to participate in a unique summer program that could lead to graduate fellowships and full-time employment. To date, two scholars were hired as employees following involvement in the scholars program, and three expressed interest in being recruited for permanent positions after their doctorate work is complete.

Top students at some of this country's best universities and the Air Force Academy spend their summer working at the Space Vehicles Directorate as part of an innovative initiative to further critical space technology areas or space sciences. They gain hands-on experience working on novel research projects. At the end of their 3 months, the students share their research results by authoring papers and presenting posters to other space scholars, mentors, and employees in the directorate.



The Air Force is looking for a few good men and women to eventually become tomorrow's research community as today's researchers retire. The directorate must plan for its future now by attracting a new generation of highly qualified graduates for upcoming research jobs.

Competitively selected by a panel of seasoned directorate mentors specializing in those space technologies considered most critical for national defense, the directorate matches the students with research opportunities at directorate facilities located at Kirtland Air Force Base, New Mexico and Hanscom Air Force Base near Boston, Massachusetts. The summer's research disciplines for space scholars involve space electronics, polarimetry, spacecraft charging, advanced dynamics and controls, space experiments launched on university satellites, advanced spacecraft components, infrared sensing, and space weather.

AFRL Completes Second Successful Range Safety Technology Demonstration from Kodiak, Alaska

The Space Vehicles Directorate's Ballistic Missile Technology (BMT) program developed and demonstrated the use of Global Positioning System (GPS)-based missile range safety systems as part of the Ballistic Missile Range Safety Technology (BMRST) program. The first demonstration flight and the subsequent certification flight show that BMRST technologies can satisfy Air Force Space Command's priority for range standardization and modernization.

The directorate's BMRST program completed its first certification flight in April 2002 during the second Quick Reaction Launch Vehicle mission, sponsored by the Space and Missile Center Detachment 12's Rocket System Launch program from the Kodiak Launch Complex in support of the Alaskan Command Northern Edge 2002 exercise. The BMRST captured, interpreted, and displayed range safety data for 100% of the 7-minute flight.

A directorate experiment demonstrated and tested a new ultra high frequency (UHF) command destruct capability during the certification flight. Missile flight control officers transmitted and verified six UHF arm/destruct command sequences to the launch vehicle during the flight. In addition, the directorate's BMT program developed and successfully demonstrated new GPS-inertial navigation system range safety flight hardware on the launch vehicle.

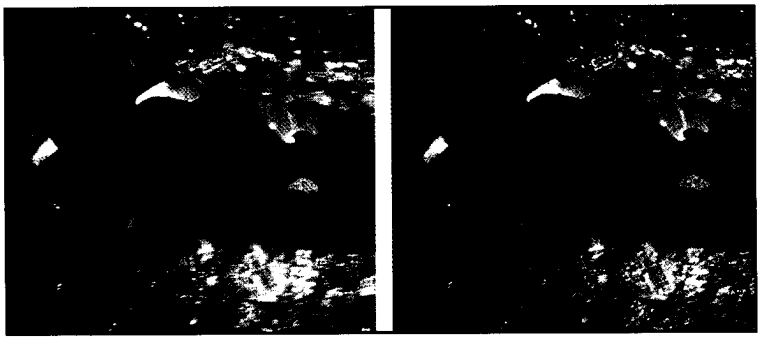
The objective of the BMRST development is to design, integrate, and test a certifiable range tracking system, which is transportable by land and air, and capable of providing system-level range safety and long-range telemetry collection. The goal of the system is to enhance and supplement launch data and public safety systems at space launch ranges. Prompt Air Force launch concepts, such as quick reaction launch, on-time takeoffs, and launch-on-demand, require flexible range safety systems like the BMRST. Plans call for additional certification testing and technology insertion.

Calibration of Fourier Transform Hyperspectral Imagery Data

Payoff Space Vehicles Directorate scientists successfully performed an on-orbit calibration of the Fourier Transform Hyperspectral Imager (FTHSI), the first flown in space. Hyperspectral imaging data has great potential for meeting warfighter requirements by determining the types of materials observed in terrain imagery.

Accomplishment Directorate scientists performed on-orbit calibrations of the spectral and radiometric performance of the FTHSI sensor, which flew on the MightySat II satellite. The spectral calibration determined the absolute wavelength associated with each of the 146 spectral wavelength bins collected by the sensor.

Directorate scientists used the validated MODTRAN atmospheric transmission code to determine the precise spectral locations of absorption features due to atmospheric water vapor and oxygen. By identifying these features in the FTHSI data, they determined the absolute wavelength of each spectral bin.



To relate the intensity of the radiance incident on the sensor to the observed signals, the scientists performed a radiometric calibration using FTHSI observations of a spatially uniform site. They measured the site's radiometric properties on the ground and determined the site's atmospheric absorption along the line of sight. The scientists validated the radiometric calibration using data collected by the well-characterized, aircraft-based NASA Jet Propulsion Laboratory instrument, AVIRIS hyperspectral data, to validate the materials present in the scenes imaged by FTHSI.

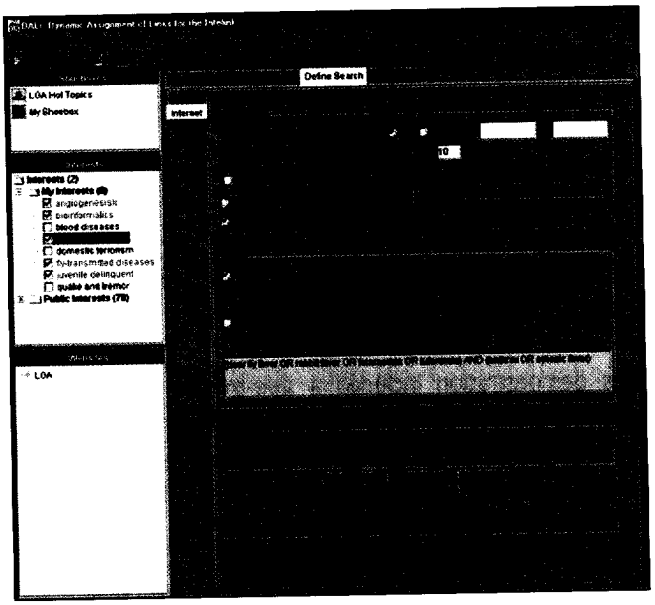
Background FTHSI demonstrated the first successful earth-observing operation of hyperspectral imaging technologies in space. To exploit the unique data collected by FTHSI, both spectral and radiometric calibrations of the sensor are required.

Technology Transfer

Information Management Assisted by Development of DALI

Payoff Managing knowledge in a real-time environment is now possible for the US Air Force and the intelligence community via a version of Dynamic Assignment of Links for the Intelink (DALI). DALI, developed by the Information Directorate, provides automated support to intelligence analysts, improving existing search technology with enhanced search results and supporting the capability to embed searches within a complete research environment.

Accomplishment The directorate awarded a Small Business Innovation Research program contract to Lynne Gilfillan Associates, Inc. (LGA) of Fairfax, Virginia, to provide automated support to intelligence analysts as they face a growing number of complex challenges. These challenges include (1) the exponential increase in the amount of information available, (2) sub-specialization among intelligence analysts, which makes it more difficult to share knowledge quickly and precisely, (3) new data sources coming on-line daily (4) intelligence analysts gathering and analyzing information against tight deadlines, and (5) the need for greater collaboration for accurate analysis.



LGA ultimately developed a solution, addressing the needs of intelligence analysts. DALI enhances existing search technology to embed searches within a complete research environment. In this environment, analysts can formulate their investigations, execute data gathering across a variety of sources, and organize and annotate the results in a collaborative environment.

DALI allows for simultaneous queries to the Internet, electronic libraries, local/enterprise databases, intranet(s), and/or secure networks such as Intelink. Users situated at local or remote locations can effectively search, retrieve, organize, categorize, analyze, collaborate, and selectively share both source materials and finished products seamlessly and systematically.

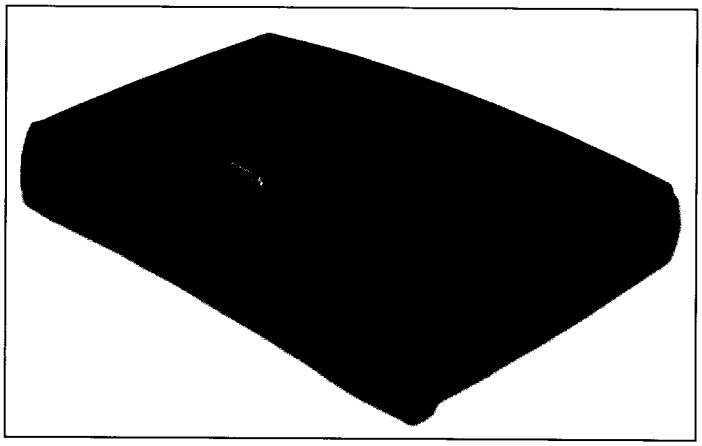
Background DALI is currently in use at the Intelink Service Management Center, the National Imagery and Mapping Agency, and several other organizations within the intelligence community. LGA has pending contracts with the American Association of Pharmaceutical Scientists, and Howard and Wake Forest Universities. The National Cancer Institute is utilizing customized versions of this technology. Commercial enthusiam for this product continues to grow, as the areas of justice, education, banking, and aerospace have expressed interest in DALI.

Commercialized Space Communication Protocol Router Demonstrated

Payoff Information Directorate researchers recently achieved a milestone in wireless Internet communications with the first commercial installation of the Space Communications Protocol Standards (SCPS) transport gateways over National Aeronautics and Space Administration's (NASA's) Advanced Communications Technology Satellite (ACTS).

Accomplishment The directorate's Information Connectivity Branch has been substantially involved with the development of the SCPS protocols over the past 4 years. The SCPS transport gateway offers up to several times the bandwidth utilization efficiency of the well-known Internet protocols, Transmission Control Protocol/Internet Protocol (TCP/IP), over a satellite channel as well as being functionally compatible with existing TCP/IP-based networks.

Ordinary, untuned TCP/IP connections generally make highly inefficient use of bandwidth over noisy channels. When researchers introduce long latencies (i.e., geostationary satellite links), these inefficiencies are even more pronounced. Global Science & Technology, Inc. (GST) is commercially developing this technology and demonstrated the first of a new product line of SCPS-enhanced network appliances.



This demonstration included a side-by-side comparison of GST's SCPS protocol product, known as SkipWare™, against an unenhanced TCP/IP. The demonstration proved conclusively that GST's SkipWare-enhanced device offers superior performance and bandwidth efficiency. The SCPS transport protocol is an enhanced flavor of modern TCP and is completely compatible with existing TCP/IP-based network infrastructure. GST specifically designed the SCPS enhancements to operate with higher efficiency in a wireless/satellite environment.

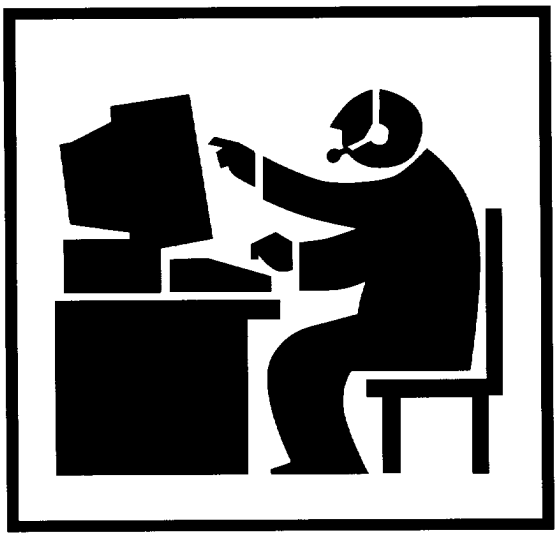
Background The directorate's Information Connectivity Branch involvement in SCPS began with configuration and management of the satellite test environment used for initial testing and verification of the protocol software. GST also demonstrated their SkipWare-enhanced devices over the NASA ACTS using the directorate's ACTS earth station located in Rome, New York.

Audio Information Extraction Tool Detects Criminal Activity

Payoff Inmates in our nation's prison system who use prison telephones to continue their criminal activity will now be caught through a tool that can automatically detect potential planned criminal activity from their conversations. The Information Directorate and Research Associates for Defense Conversion (RADC) jointly developed a tool that automatically extracts information from conversational speech. The work, funded by the National Institute of Justice (NIJ), addresses a troublesome telephone problem within both federal and state prisons.

Accomplishment The directorate's Multisensor Exploitation Branch and RADC engineers developed an information extraction capability, called Telephone Abuse Detection Demonstration (TADD), to detect criminal activity conducted over prison telephones by inmates. The TADD uses several audio technologies to detect and recognize credit card fraud, drug solicitation, harassment, and threats to witnesses and victims.

TADD uses a spoken digit string length recognizer (over 12 digits) to detect credit card fraud and uses speaker recognition technology to recognize threats to witnesses, victims, and public officials. To further recognize criminal activity, such as planning drug solicitation, the engineers developed a speech recognizer to alert prison officials of such conversation. Detecting these types of conversations, the TADD can alert prison officials to monitor the conversation or terminate the call.



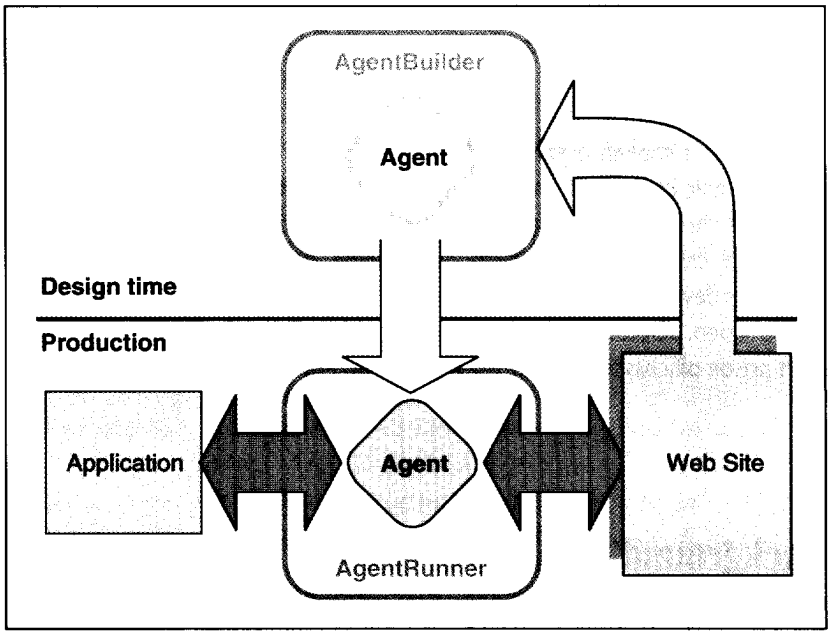
Background The directorate's test results on a controlled database of conversations using carbon button-type phones normally found in prisons, demonstrated performance ranges from 76 to 100% in detection of the above activities. Although the directorate developed TADD for the NIJ and the Federal Bureau of Prisons, the technology has direct information extraction application to the Air Force intelligence, surveillance, and reconnaissance-monitoring mission and to Blue Force communication security.

Agents Technology Goes Commercial

Payoff The University of Southern California/Information Sciences Institute licensed a software agent under the Defense Advanced Research Projects Agency (DARPA) Control of Agent Based Systems (CoABS) program to Fetch Technologies, Inc. in California, a company that provides innovative data integration solutions. Fetch Technologies' research led to the development of the Fetch Agent Platform, a system for accessing information directly from Web solutions.

Accomplishment Since web sites present data visually, users need software agents to navigate through sites and extract data in a structured form to pipe into applications. The DARPA Information Technology Office funded the CoABS program that the Information Directorate's Dynamic Command and Control Technology Branch technically managed. The University of Southern California/Information Sciences Institute developed information retrieval agents and adaptive Web wrapper technology under the CoABS program.

The Fetch Agent Platform is a simple, powerful, and efficient way to integrate Internet-available data sources. The platform consists of two components: AgentBuilder (the design-time component) and AgentRunner (the run-time component). Using proprietary artificial intelligence techniques, the Fetch Agent Platform creates a two-way bridge connecting software applications with any web site or Internet-available applications.



The platform is a stand-alone licensable software product that users can apply to a variety of information-gathering tasks. Applications include intelligence, wireless devices, sales, information integration, and data aggregation. Fetch Technologies uses artificial intelligence techniques that allow users to build agents by example, ensure that the agents accurately extract data, continually verify agents to avoid failures when sites change, and automatically repair agents in response to web site changes.

Background Fetch Technologies started as a spin-off from the research labs at the University of Southern California Information Sciences Institute. The company has a number of private sector customers such as Enviz, BizRate, and Voxicom. Several government agencies in the intelligence sector use Fetch products as well as the US Energy Information Administration. Additional information on Fetch Technologies and its products is available at *http://www.fetch.com/contact-generalinfo.asp.*

Web-based Information Management Tool Designed by AFRL Engineers

Payoff Historically, program managers had rooms full of case files, spreadsheets, and slide shows available to track a simple research and development contract. Today, thanks to the work of two Information Directorate engineers, program managers can find all the pertinent information they need in a "JIFFY"—a Web-based financial and technical monitoring and document repository tool. The program, designed for a distributive work environment, can do more with less resources. It keeps more people in the loop while working from the same set of data.

Accomplishment Retrieving current financial, technical, and programmatic information related to ongoing contracts has been a source of frustration for contract program managers and a host of others responsible for monitoring contracts for years. Oftentimes, the information is nonexistent, outdated, buried in a stack of paper records, or in a cryptic spreadsheet. Directorate engineers recognized these shortcomings and developed a Web-based information management tool for technical programs called JIFFY.

Background All users share the burden of keeping data up-to-date. The goal is for contracting personnel to input contractual documents, engineers to input technical reviews, and the principal investigator (PI) to provide financial and technical progress updates. Government engineers can then use the site to monitor the PI's submissions and create paperwork for new contract actions.

JIFFY also features a digital case file repository for all paperwork and reports associated with the contract including contract/grant/cooperative agreement documents/mods, source selection letters, proposals, costing, statements of work, contract data requirements lists, Defense Advanced Research Projects Agency orders, and a host of other pertinent data items. These documents are now available to any registered user with the correct permissions and access to a Web browser.

With all the data and documents in a central repository, endless possibilities exist for management, technical, or contracting personnel to view the data. Users can easily build charts in HyperText Markup Language or Excel showing roll-ups of funding figures. Graphical views, including schedule bar charts, financial line graphs, and funding profile bar charts, are available for each contract.

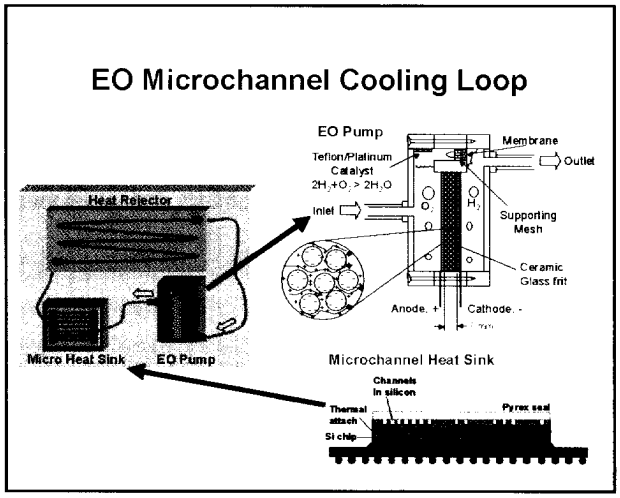
JIFFY uses a Secure Socket Layer technology with a 128-bit encryption to protect transmissions between the Web browser and the JIFFY server. Five levels of permissions are available ranging from the full access of "System Admin" to the more restrictive "View Only."

Electrokinetic MicroCoolers: A DARPA-AFRL-Stanford-Intel Success Story

Payoff A major limitation in high-speed electronic parts for computers, photonics, information and telecommunications systems is removal of excess heat. An Information Directorate research project, sponsored by the Defense Advanced Research Projects Agency (DARPA) and with support and collaboration of Stanford University and Intel Corporation, developed a closed-loop microchannel cooling system using electro-osmotic (EO) pumps. This new system dramatically improves electronics and photonics heat sink performance.

Accomplishment The directorate recently developed a novel cooling system to integrate onto the backside of an electronic or photonic device. Stanford University demonstrated the success of this technique by cooling a 30 watt (W)/cm^2 chip and a 100 W/cm^2 device.

To demonstrate the cooling of an actual electronic device in an existing computer, Stanford teamed with Intel Corporation to integrate this technology into a Sony VAIO (video audio integrated operation) laptop computer. Stanford integrated the EO pump and cooling system within the laptop to cool an 8 W working electronic chip.



Background Computer heat sinks, such as fin arrays and heat pipes, are currently much larger than the silicon chip itself and continue to grow in size. The increasing heat generation rates associated with increased chip speed targeted by the International Technology Roadmap for Semiconductors are driving this trend.

No compact and practical solution has been developed to date that can cool high-power electronic devices in a small, efficient, and cost-effective configuration. Consequently, manufacturers are forced to place discrete memory, video, and power components farther away from the microprocessor, thus degrading system performance.

The fundamental premise of this technology is to pump liquid through chip-sized microchannel heat sinks that attach to the chip backside to remove 100+ W of heat per square centimeter. Manufacturers fabricate these heat sinks using microelectromechanical systems technology.

These heat sinks are part of a hermetically sealed, closed-loop system featuring a novel and compact EO pump, forced two-phase convection in the heat sink, and a remote condenser. Microchannel configurations alleviate on-chip hot spots more effectively than copper and diamond heat spreaders.

This cooling system minimizes the volume required at the chip backside, adds much more flexibility to computer system design, and requires no moving mechanical parts (thus increasing system reliability). It can also be readily scaled to higher power requirements associated with the continued advancement in component technology.

The directorate, Stanford, and Intel were so successful that the principal investigators from Stanford and Intel formed a company called Microflux to commercialize this technology. This company negotiated a license for the Stanford patent and secured funding for this start-up venture.

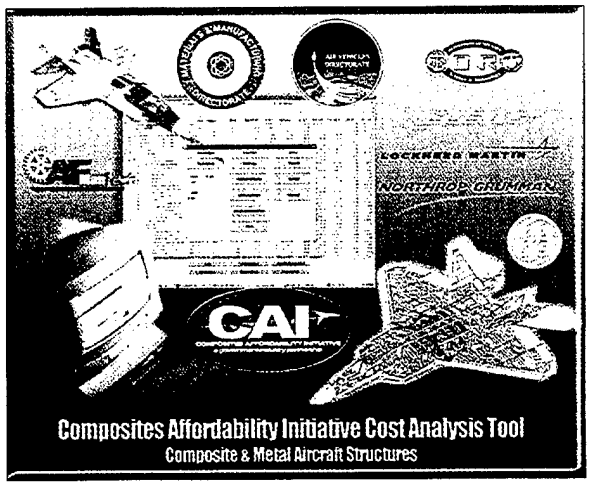
Composites Affordability Initiative Cost Analysis Tool

Payoff The Composites Affordability Initiative Cost Analysis Tool (CAICAT) offers the aerospace industry the opportunity to improve the decisions made during the preliminary design phase by enabling them to review 10 times as many options as before. If aerospace engineers need to compress the preliminary design phase, CAICAT allows them to conduct a set number of projections in one-tenth the time compared to traditional methods.

The CAICAT's real success is its extensive use in industry. Composites affordability initiative (CAI) industry team members used CAICAT on a growing list of systems such as the Joint Strike Fighter, F-22 Raptor, F-16, F-18 E/F, and more.

Accomplishment The CAI Team consists of the Materials and Manufacturing Directorate; the Air Vehicles Directorate; the Office of Naval Research; and prime aerospace contractors Boeing, Lockheed Martin, and Northrop Grumman. The team developed and demonstrated a cost analysis tool that allows airframe designers to save money in the design of airframe structural concepts.

CAICAT enables increased cost reductions by identifying the most affordable composite airframe structural concepts earlier in the design phase with greater dependability than previously possible. In validations by CAI team members, nearly 75% of the structures and assemblies evaluated fell within 10% of actual costs, and more than a third were within 2%.



Background The Materials and Manufacturing Directorate's Manufacturing Technology Division established the CAI Team in 1998 to decrease the costs associated with the manufacture of composite structures, which are considered essential to high-performance aircraft advancement. Prior to CAICAT, aerospace engineers obtained cost estimates using weight-based parametric models—cost estimates using the weight of the proposed structure.

The CAI Cost Team developed CAICAT by modifying direct cost model software, developed by a company called Galorath, to include existing and emerging composite fabrication/assembly processes including hand lay-up, vacuum-assisted resin transfer molding, fiber placement, co-resin transfer molding, and Z-pinning as well as some state-of-the-art metal processes such as high-speed machining. Galorath also developed specific modules that described the process steps, their variables, and related costs.

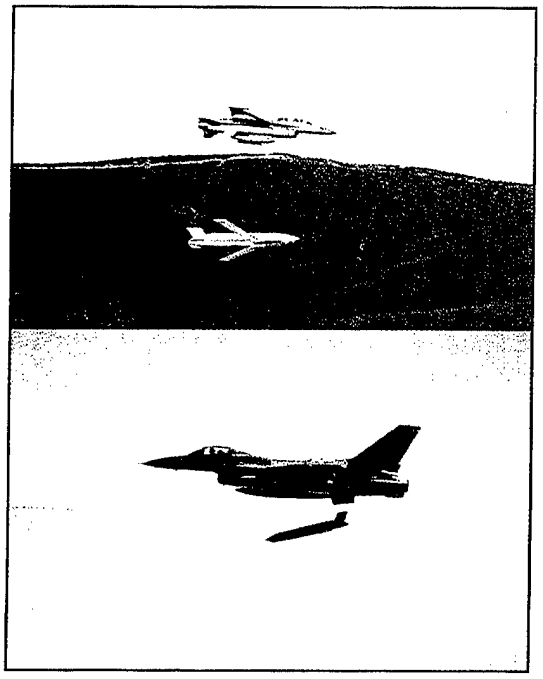
Aerospace industry leaders supplied cost data required for the modules, while directorate engineers merged processing data and costs from the major aerospace contractors to develop industry-accepted cost standards. The CAI Cost Team customized indirect cost and factory simulation models from commercial products by vendors MCR and AutoSim, respectively. The Navy developed the Operation and Support module, while the CAI Cost Team developed the research, development, test, and evaluation module.

Interactive Missile Design–Manufacturing Network Accelerates Spiral Development Times Four

Payoff The Interactive Missile Design/Web-based Design Environment (IMD)/(WDE) system offers significant and invaluable savings in design time and cost. This dynamic real-time design environment optimizes the process by collaborating users such as military customers, industry designers, and manufacturers. The IMD/WDE system saved Lockheed Martin Missiles and Fire Control (LMMFC) more than $3 million to date, just in the conceptual missile design process alone.

Future payoffs include the Supersonic/Hypersonic Vehicle Design Simulation system, which is a similar Web-based, conceptual design environment for high-speed vehicles. Much like the missile design environment, engineers can design these vehicles four times faster than in previous design processes and analyze the design for quick turnaround in what-if scenarios.

Accomplishment LMMFC of Orlando, Florida, under a contract with the Manufacturing Technology (ManTech) Division of the Materials and Manufacturing Directorate, developed an interactive design-manufacturing network for missiles, referred to as the IMD system. IMD, often referred to as "spiral development," helps engineers perform missile design up to four times faster than previous design systems.



LMMFC uses the IMD software to integrate multiple design disciplines with both residual and supplier manufacturing knowledge to perform an integral role in the preliminary and conceptual missile design process. Recent LMMFC projects in which IMD significantly reduced design time for the Air Force and Army include the Extended Range Javelin, Common Modular Missile, Advanced Fire Support system, Precision Attack Munitions, and Multi-Role Armament and Ammunition systems.

Background The IMD system is an application based upon the commercially available Adaptive Modeling Language (AML), created by TechnoSoft, Inc. of Cincinnati, Ohio. Using AML as the underlying architecture, IMD is a cross-platform, multi-disciplinary design system that integrates system-level missile design and analyses with cost estimation.

The IMD system has the ability to analyze cost and performance trade-offs that are necessary for cost-as-an-independent-variable studies. This analysis significantly reduces conceptual and preliminary design time, which in turn, reduces overall program cycle time. This reduction in program cycle time leads to reductions in overall cost and time to market.

IMD is an even more powerful design tool when enhanced with TechnoSoft's real-time Internet-based collaborative design extension, known as WDE. ManTech, the Air Vehicles Directorate, and Lockheed Martin originally developed the WDE software under a Dual-Use Science and Technology contract.

The IMD/WDE integration allows for the interaction of many geographically dispersed designers and analysts working on the same WDE server-based model. The collaboration of these dispersed engineers and designers to work together, from the initial design concept to a virtual prototype, significantly saves valuable design time. Additionally, the IMD/WDE incorporates subcontractors, teammates, suppliers, manufacturers, and customers into the design process to offer design input.

Air Force Technology Transfer Program

Payoff The Air Force (AF) Technology Transfer (T^2) program offers partners an outstanding opportunity to leverage AF technology and expertise to achieve technical solutions and significant cost savings, while enhancing their economic competitiveness. This leverage consists of tailored opportunities for access to advanced technology, the unique chance to work directly with top AF scientists and engineers, and the invitation to take advantage of specialized research and development facilities and equipment.

Accomplishment The AF T^2 program posted the revised AF Technology Transfer Handbook on the AFRL web site and developed guidelines for processing memorandums of agreements/memorandums of understanding. The T^2 program assumed program management responsibility for the Department of Defense Partnership Intermediary, TechLink; developed and implemented a Web-based system for reporting technology transfer activity to the Defense Technology Transfer Information System; and developed brochures describing the T^2 program, Cooperative Research and Development Agreements, and Education Partnership Agreements. To find out more about the AF T^2 program, please visit the web site at *www.afrl.af.mil/techtran.*

Background The Headquarters T^2 management team, located in AFRL, assures that AF science and engineering activities promote the transfer and/or exchange of technology with state and local governments, academia, and industry to create jobs, improve productivity, and increase competitiveness while supporting the AF mission. The primary objective for the program team is to enhance the management of technology transfer through streamlining program execution, providing guidance through policy initiatives and fostering an enviroment conducive to T^2.

AFRL's 10 major research sites located throughout the United States, other AF laboratories and/or technical activities, and the Air Force Materiel Command centers carry out the AF T^2 program mission. Partners include universities and industry, with whom AFRL invests almost 80% of the budget. Customers include the AF Major Commands, who operate and maintain the AF weapon systems. Other AF organizations with active T^2 programs include Product Centers, Test Centers, Air Logistic Centers, and Battlelabs.

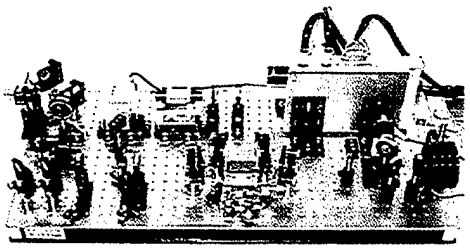
Mid-IR Periodically Poled Lithium Niobate Infrared Countermeasures Laser

Payoff Sensors Directorate scientists developed periodically poled lithium niobate (PPLN) technology and successfully transferred it to industry for construction of a compact and rugged mid-infrared (IR) brassboard laser. This mid-IR laser source is ready for insertion into fielded infrared countermeasure (IRCM) systems and should provide a major advance in IRCM capabilities.

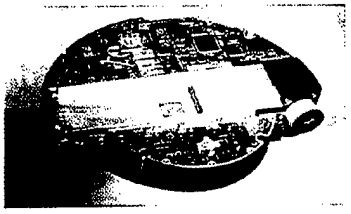
Accomplishment Directorate personnel helped develop and transfer to industry an efficient, compact, low-cost, and broadly tunable technique for generating mid-IR laser radiation. Basic directorate research demonstrated a breadboard laser that generated the power and tunability needed for aircraft protection from infrared missiles.

The approach used PPLN for broadband frequency conversion in the mid-IR spectral region. The directorate then transferred this technology to Northrop Grumman, who assembled a packaged brassboard laser device that successfully performs the countermeasure function.

Breadboard PPLN Optical Parametric Oscillator 2 ft x 4 ft



Brassboard Northrop Grumman Viper® Laser (not to scale)



Background Compact, tunable, room temperature, solid-state laser sources operating in the mid-IR (1.5-5 μm) spectral region are of interest for a number of applications such as eye-safe laser radar, remote sensing, and IR countermeasures. This spectral region is difficult to generate, particularly by solid-state lasers.

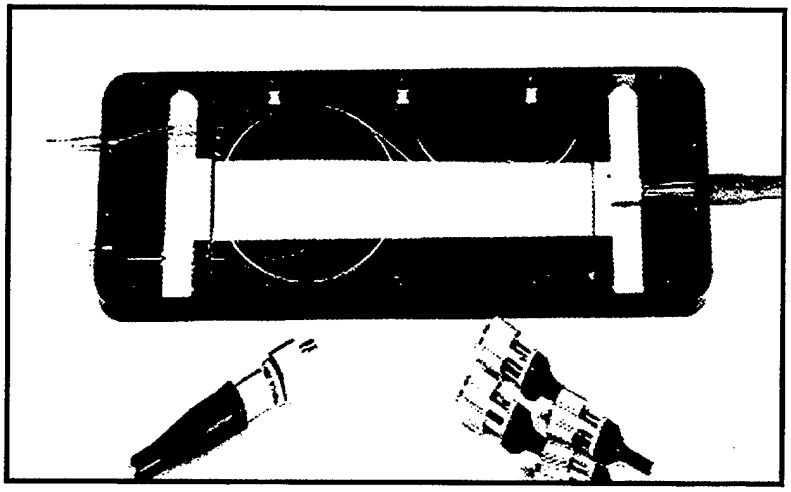
Directorate-led research developed a technique to fabricate PPLN and demonstrated that PPLN could efficiently generate high-power, broadly tunable, mid-IR output in an optical parametric oscillator when pumped by a simple off-the-shelf neodymium pump laser. Breadboard laser systems built in-house and by industry under contract demonstrated multiple watts of tunable mid-IR output.

With directorate help, researchers at Northrop Grumman successfully assembled and demonstrated a brassboard laser system based on the PPLN device. The brassboard device successfully met all requirements, including volume and shape, and is ready for direct substitution into existing Northrop Grumman directed IRCM systems.

Integrated Optics Rotation Sensor

Payoff The Sensors Directorate managed a Small Business Innovation Research Phase II project with Rice Systems, Inc. of Irvine, California, to develop and demonstrate a lightweight, compact, glass-on-silicon optical gyroscope with an optics package slightly larger than a credit card. Directorate engineers needed the Integrated Optics Rotation Sensor (IORS) for the development of a low-cost, environmentally rugged optical gyroscope for a variety of military rotation sensing requirements. The Defense Advanced Research Projects Agency funded this project under the Technology Reinvestment project.

Accomplishment Rice Systems continued development of the IORS—"gyro on a chip" concept—that led to innovations for both military and commercial applications. These applications include inertial navigation, satellite guidance and control, flow diagnostic sensors, biomechanics, materials inspection, and the characterization of protein crystal growth.



Air Force (AF) system applications include low-grade navigation, and guidance and control applications such as munitions and platform stabilization requiring small size and low weight instrumentation. Directorate engineers estimate a potential savings of up to 75% of the cost for an inertial measurement unit for AF weapons systems.

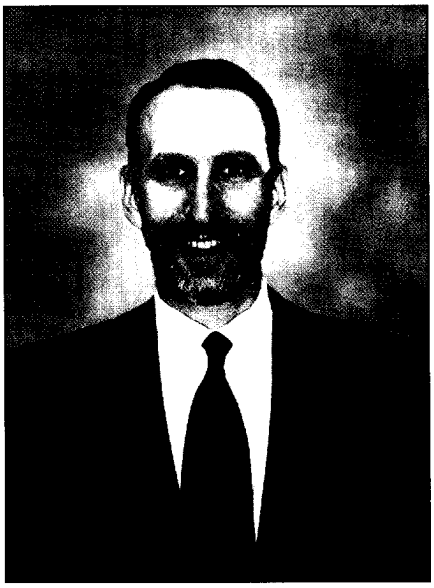
Background Rice Systems' engineers identified many important commercial applications for the IORS such as automotive, robotic, munitions, and medical applications. For example, medical devices, such as wheel chairs that must stay upright, could use the technology to implement some type of coarse navigation system. Angular rate sensing in automobiles is another possibility. Rice Systems' engineers are also investigating IORS as a way to stabilize the human body to help prevent falls of the elderly.

Rice Systems is currently developing several follow-on devices, which are more commercially applicable. These devices include a lossless splitter for telecommunications and a sensor for the micropropulsion systems of microsatellites.

Awards and Recognition

Dr. Michael Berman Elected as AAAS Fellow

Payoff Members of the American Association for the Advancement of Science (AAAS) recently bestowed Fellow status on Dr. Michael Berman, a program manager with the Air Force Office of Scientific Research (AFOSR). The association recognized Dr. Berman's outstanding contributions in the areas of rocket propellants, chemical lasers, and atmospheric chemistry research.



Accomplishment Dr. Berman is a respected and highly regarded program manager at AFOSR's Chemistry and Life Sciences Directorate. The AAAS honored Dr. Berman for his "outstanding leadership, advocacy, and support of chemical physics research and for contributions to applications of laser methods to chemical kinetics and spectroscopy." AAAS members bestow Fellow status upon a member based on "efforts for the advancement of science and engineering, which are scientifically or socially distinguished."

Background Membership in AAAS is open to all individuals who support the goals and objectives of the association and are willing to contribute to the achievement of those goals and objectives. The AAAS is the world's largest general science organization and publisher of the peer-reviewed journal *Science*.

With more than 138,000 members and 275 affiliated societies, AAAS serves as an authoritative source for information on the latest developments in science and bridges gaps among scientists, policy-makers and the public to advance science and science education. Founded in Philadelphia in 1848, the AAAS is among the oldest societies in America. Many of today's most prestigious and influential scientific societies have their historical origins in AAAS.

Colonel T. Jan Cerveny Receives One of Germany's Highest Military Honors

Payoff The Federal Republic of Germany bestowed one of its highest military honors, the Silver Cross of Honor of the Federal Armed Forces, on Colonel T. Jan Cerveny. Her efforts single-handedly improved and strengthened the relationship between the US and Germany. Germany rarely awards the Silver Cross of Honor of the Federal Armed Forces, which is similar in rank to the US Legion of Merit, to a non-German.

Accomplishment Col Cerveny, PhD, Director of External Programs and Resources Interface Directorate at the Air Force Office of Scientific Research (AFOSR), earned the nomination for reviving the Engineer and Scientist Exchange program between the US and Germany during a period when it became increasingly difficult to secure exchange slots in the US. Since 1963, more than 1,500 engineers, military officers, and civil servants have participated in a 1-year scientific or technical assignment in each other's countries.

Background Heading up AFOSR's External Programs and Resources Interface Directorate since 1995, Col Cerveny worked closely with Germany. German officials credit her with orchestrating a memorandum of understanding between the two countries and allowing administrative officers and personnel with a particular specialization, such as geology and psychology, to also participate.

Col Cerveny oversees educational, minority, and international programs for the Air Force in universities, industry, and Air Force laboratories. At the national level, Col Cerveny coordinates academic and special legislative programs with the National Science Foundation, other Department of Defense and federal organizations, and non-federal educational institutions.

Dr. Edmond M. Dewan Receives Guenther Loeser Memorial Award

Payoff Dr. Edmond M. Dewan's Dewan Model is the code at the core of the Airborne Laser (ABL) turbulence forecasting electronic atmospheric decision aid, which resulted in a direct Air Force operational system application with potentially long-term benefits in this era of new high-energy systems. Dr. Dewan, a scientist with the Space Vehicles Directorate at Hanscom Air Force Base (AFB), Massachusetts, contributed essential and significant scientific and modeling information to the Air Force in operations involving ABL, Strategic Defense Initiative (SDI), and future surveillance, laser communication, and laser directed energy applications.

Accomplishment Dr. Edmond M. Dewan, a scientist funded by the Air Force Office of Scientific Research's (AFOSR's) Physics and Electronics Directorate, recently received the Guenther Loeser Memorial Award. The award, named for Loeser in 1955 after he lost his life conducting meteorological research for the Air Force, is the highest award a scientist can receive at Hanscom AFB.

Hanscom AFB recognized Dr. Dewan for his unusually wide array of research in such scientific fields as special relativity, satellite scintillation effects, ball lightning, cybernetics, and atmospheric physics. Dr. Dewan spent most of his career focusing on atmospheric physics, specializing in the area of waves and turbulence, and credits much of his success in atmospheric waves to AFOSR's many years of sustained funding.

Background Dr. Dewan started his career with AFOSR in 1957 and published over 100 papers. Between the years of 1957 through 1972, Dr. Dewan concentrated his research in the areas of special relativity, satellite scintillation effects, ball lightning, cybernetics, electroencephalography, rapid eye movement sleep, and non-linear oscillations in biology.

Since 1972, Dr. Dewan concentrated on atmospheric physics in the areas of waves and turbulence and preparing environmental impact statements for Air Force operations in the stratosphere. He participated in field experiments and theoretical work to determine the vertical turbulent transport of pollutants in the stratosphere. An important finding of this work was that turbulent transport in the stratosphere is an order of magnitude larger than was believed at the time. Subsequent work in turbulence concerned optical turbulence in connection with the SDI and continues now in support of the ABL, resulting in the Dewan Model.

The Dewan Model converts radiosonde data into optical turbulence profiles. The radiosonde is a balloon-borne instrument platform with radio-transmitting capabilities. The radiosonde contains instruments capable of making direct measurements of air temperature, humidity, and pressure with height, typically to altitudes of approximately 30 km. Due to the effectiveness and compactness of the model, the Air Force incorporated the Dewan Model into the first operational turbulence-forecasting model for the ABL.

Dr. Dewan's gravity wave model simulates the turbulent layers in the atmosphere. He is best known for his work in experimental and theoretical findings regarding the universal characteristics of the spectra of gravity waves.

Dr. Scott Robert Manalis Receives Presidential Award

Payoff The Presidential Early Career Award for Science and Engineering (PECASE) is the highest honor given a scientist by the United States (US) government. This Presidential award embodies the high priority the government places on maintaining the US leadership position in science by producing outstanding scientists and engineers and nurturing their continued development. President Bill Clinton established the PECASE in 1996 to "nurture and support" America's finest young scientific minds.

Accomplishment The National Science and Technology Council recently awarded Dr. Scott Robert Manalis, an Air Force Office of Scientific Research-funded engineer and a professor of media arts & science and bioengineering at the Massachusetts Institute of Technology, the PECASE in a White House ceremony. Dr. Manalis received recognition for making significant contributions in the development of innovative scanning probe nanotechnologies that are leading to new microelectronic devices and to the detection of structure and structural changes in deoxyribose nucleic acid (DNA) and proteins.

Background Dr. Manalis' recent research focused on the development of unique surface modification strategies for nanoscale sensors that will enable the detection of biological components at levels down to single molecules. He hopes to create revolutionary new tools for advancing molecular biology.

Dr. Manalis hopes to obtain direct information on DNA or protein molecules by binding them to silicon transistors or tiny cantilevers. His dream may be 5 to 15 years from reality.

Dr. Manalis plans to stick a probe into a cell, connect it to a computer, and get real-time information on the cell's proteins and genes. Such a tool would be invaluable to molecular biologists, replacing weeks or months of laboratory analysis. His work will significantly impact the way scientists analyze, control, and detect chemical and biological species.

Dr. Raffaello D'Andrea Receives PECASE Award

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Accomplishment The National Science and Technology Council recently awarded Dr. Raffaello D'Andrea the PECASE in a White House ceremony. Dr. D'Andrea is an Air Force Office of Scientific Research-funded engineer and a Cornell University mechanical and aerospace engineering professor.

The National Science and Technology Council recognized Dr. D'Andrea as a leader in the area of theoretical and experimental control systems engineering—a field that deals with the problem of analyzing and designing feedback systems that exhibit desirable performance characteristics in the presence of inevitable modeling errors. Dr. D'Andrea's research contributed to advances in the robust control of feedback systems with applications to the cooperative control of distributed autonomous vehicles in dynamic, uncertain, adversarial environments.

Background Control systems are everywhere. An automobile's cruise control is the simplest example of a feedback control system. As the car moves up and down a hill, the throttle automatically changes so the car maintains a constant velocity. Other items that use simple control systems include compact disc players, disk drives, and cellular telephones.

Power plants or high-performance vehicles, such as airplanes, contain very complicated control systems. Dr. D'Andrea's research focuses on controlling complex systems by building mathematical models. Military and civilian aviation communities can use Dr. D'Andrea's research in this critical technology when dealing with flight and jet engine control problems.

Directed Energy Directorate Scientist Receives Distinguished Civilian Service Award

Payoff Dr. R. Russell Butts, of the Directed Energy Directorate's Airborne Laser Technology Branch, received the Department of Defense (DoD) Distinguished Civilian Service Award for exemplary public service in leading the development of laser beam control technologies. The award is the highest given to career civilian employees by the Secretary of Defense for exceptional duty and extremely significant contributions in science, technology, or administrative fields that increased efficiency, economy, or performance within the DoD.

Accomplishment Dr. Butts' research team developed crucial Airborne Laser (ABL) technologies that will enhance America's missile defense capabilities. He directed his team to validate beam control capabilities corresponding to the "speed of light" destruction of ballistic missiles in the boost phase.

Dr. Butts joins two other directorate scientists who received this award over the past 4 years. In 1999, Dr. William L. Baker, the directorate's chief scientist, and in 1997, Dr. Robert Q. Fugate, a senior scientist for atmospheric compensation, each received this honor.

Background As principal investigator of advanced ABL beam control techniques, Dr. Butts' team conducted two major congressionally-mandated laser beam control demonstrations in direct support of the $1.3B ABL acquisition program. These demonstrations conclusively validated ABL laser beam control performance at required design points.

The Secretary of the Air Force certified the ABL acquisition program before Congress in 1999 based on the beam control demonstration performed by Dr. Butts' team. The success of the beam control demonstration played a key role in the restoration of ABL program fiscal year 2001 funding.

In order to counter the effects of turbulence on the ABL laser beam, Dr. Butts directed his team to conduct two major ground-to-air demonstrations to verify the ABL system could pre-shape the beam for effective propagation. Under his guidance, the ABL team demonstrated the system could attain up to a six-fold increase in energy on target as compared to performance without atmospheric correction.

Dr. Butts' team successfully demonstrated effective laser beam correction for atmospheric turbulence. The extensive efforts of Dr. Butts significantly impacted the revolution in directed energy weapons, assuring asymmetric superiority over potential adversaries.

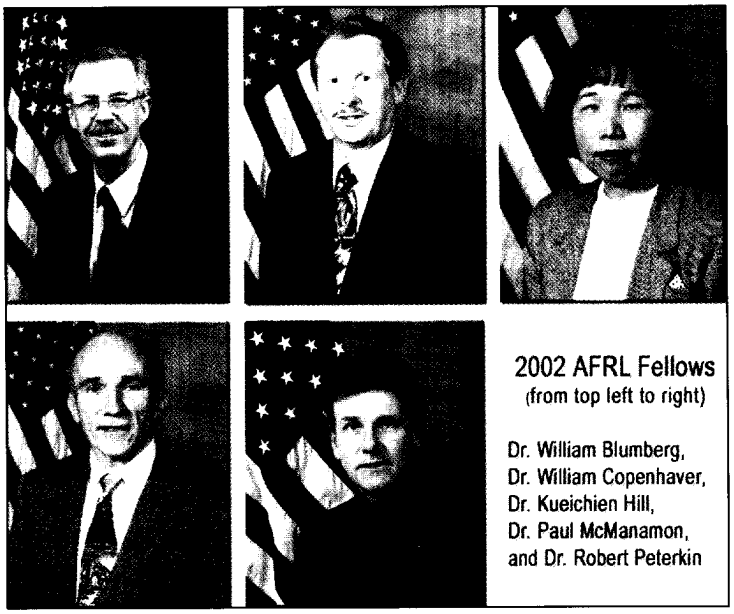
AFRL Names Five New Fellows

Payoff Dr. William Blumberg, Space Vehicles Directorate; Dr. William Copenhaver, Propulsion Directorate; Dr. Kueichien Hill, Sensors Directorate; Dr. Paul McManamon, Sensors Directorate; and Dr. Robert Peterkin, Directed Energy Directorate, were recently selected as AFRL Fellows. The men and women recognized as AFRL Fellows ensure technological superiority for the Air Force through their significant scientific achievements and personal commitment to excellence.

Accomplishment Dr. Blumberg is responsible for the Battlespace Environment Division's overall technical direction in specifying, forecasting, mitigating, and exploiting environmental impacts on Air Force space systems.

Dr. Copenhaver's expertise is in the area of compression system aerodynamics. His breakthroughs in jet engine stall prevention have had great impact on both military and commercial aircraft.

Dr. Hill is renowned for work in computational electromagnetics (CEM), and her research has revolutionized radar cross-section modeling for America's stealth technology. CEM design tools are directly influencing future low observable weapon systems that provide our combat forces with a significant military advantage.



2002 AFRL Fellows
(from top left to right)

Dr. William Blumberg,
Dr. William Copenhaver,
Dr. Kueichien Hill,
Dr. Paul McManamon,
and Dr. Robert Peterkin

Dr. McManamon, a leader in electro-optical systems, is recognized for his work in optical phased arrays and laser flash imaging. He is currently developing multidiscriminate electro-optical sensors, including multifunction laser radar technology, needed to detect, track, and identify difficult targets.

Dr. Peterkin's research in computational plasma physics for states of geometric complexity significantly advanced the development of high-power microwave systems. Additionally, he serves as chief scientist for the Department of Defense High Performance Computing Modernization program.

Background The AFRL Fellows program recognizes and rewards the laboratory's most outstanding in-house scientists and engineers for their accomplishments and technical excellence. Each Fellow receives a special $100,000 grant for the first 2 years following selection. The grant serves to assist in further self-development and additional research.

Military and civilian scientists and engineers, comprising about 55% of the AFRL workforce, are eligible for selection as an AFRL Fellow. Eligible participants must be assigned to AFRL for the past 3 consecutive years and have at least 7 years of active federal service. Participants must perform the recognized work at the laboratory or at one of its predecessors.

Dr. Post Installed as President of the Human Factors and Ergonomics Society

Payoff The Human Factors and Ergonomics Society (HFES) installed Dr. David L. Post of the Human Effectiveness Directorate, as President in October 2001. Dr. Post is also a Fellow of HFES.

Accomplishment The HFES is the primary technical society for human factors and ergonomics professionals in North America, representing roughly 5,000 members from around the world with many in AFRL. Dr. Post plans to focus the society's leadership on updating the HFES strategic plan and integrating the plan with decision-making processes during his 1-year term in office.

Background Dr. Post, Chief of the directorate's Visual Display Systems Branch, Crew System Interface Division, leads research and development efforts to enhance warfighter vision and visual interfaces to improve weapon system effectiveness during day and night operations. He received his doctorate in Industrial Engineering and Operations Research from Virginia Polytechnic Institute and State University in 1983. Dr. Post has been awarded two patents and produced more than 50 publications.

Dr. Post is also a member of the Optical Society of America, the Society for Information Display, the Inter-Society Color Council, and the Board of Governors for the American Association of Engineering Societies. He referees for several journals and served as Associate Editor for Vision and Human Factors for the *Journal of the Society for Information Display*, Advisory Editor for *Displays*, and editorial board member for *Human Factors*.

Dr. Kristen K. Liggett Receives the 2001 Stanley N. Roscoe Award

Payoff The Aerospace Human Factors Association, a constituent organization of the Aerospace Medical Association, awarded Dr. Kristen K. Liggett the 2001 Stanley N. Roscoe Award for the best doctoral dissertation in Aerospace Human Factors. Dr. Liggett, a crew systems research engineer with the Crew System Interface Division of the Human Effectiveness Directorate, won the award for her PhD dissertation, "The Effect of Helmet-Mounted Display Symbology on the Opto-Kinetic Cervical Reflex, Frame of Reference, and Pilot Performance."

Accomplishment Dr. Liggett's research focused on frames of reference that pilots use to determine their spatial orientation and how this can impact the design of helmet mounted display (HMD) attitude symbology. The use of HMD attitude symbology is important because it is the information that pilots use to maintain their orientation.

Pilot spatial disorientation (SD), or loss of spatial orientation, continues to be a problem in today's aircraft and is costly in terms of lives and aircraft lost. Dr. Liggett is continuing work along those same lines as the program manager of an SD program designed to address the added benefits of utilizing multiple sensory inputs (visual, audio, and tactile) to enhance pilot spatial orientation.

Dr. Liggett submitted her research to the *Aviation, Space, and Environmental Medicine Journal* in the form of two journal articles. She also submitted her research to the Human Factors and Ergonomics Society in the form of a proceedings article for their 2001 Annual Meeting.

Background Dr. Liggett received her PhD in engineering from Wright State University in 2000 through the Dayton Area Graduate Studies Institute program. While at Wright State University, Dr. Liggett received the Graduate Student Excellence Award and was the first graduate from the Humans in Complex Systems Focus Area.

Dr. Liggett is a member of the Aerospace Medical Association, Human Factors and Ergonomics Society (HFES), Aerospace Systems Technical Group of HFES, Southern Ohio Human Factors and Ergonomics Society, Tau Beta Pi (Engineering Honor Society), Association of Aviation Psychology, and the Society of Women Engineers. Dr. Liggett published 39 technical papers and journal articles, and coauthored a chapter in the *Handbook of Aviation Human Factors*.

NASA Astronauts Recognize AFRL Altitude Protection Research

Payoff Dr. Jim Webb, a Wyle Laboratories lead scientist on contract with the Human Effectiveness Directorate at Brooks City Base, Texas, recently received the prestigious "Silver Snoopy," the National Aeronautics and Space Administration (NASA) Astronauts' Personal Achievement Award. NASA commended Dr. Webb for his role in developing and transitioning exercise-enhanced preoxygenation techniques.

Accomplishment NASA successfully incorporated these directorate-developed techniques into operational International Space Station (ISS) procedures, including additional mild exercise, to more effectively prepare astronauts for extravehicular activity (EVA). This resulted in the reduction of the previous 3.5 to 4.0 hour pre-breathe time by 30% for every EVA. Given the large number of EVAs performed during ISS construction, the time savings achieved by using exercise-enhanced preoxygenation procedures greatly increases astronaut productivity aboard the ISS.

Background NASA's "Silver Snoopy" Award originated in 1968 as recognition for individuals who have performed an outstanding effort contributing to the success of manned space flight missions. To meet the award's criteria, the recipient's work must be oriented to flight safety or mission success. The recipients performance must be of an outstanding nature to distinguish his or her particular area of responsibility, and it must be meaningful in its contribution to flight safety or success of the mission.

The coveted "Silver Snoopy" Award consists of a silver pin in the form of Snoopy garbed in space helmet and space suit, a certificate, and a letter of commendation personally signed and presented by an astronaut citing appreciation for the outstanding performance of each recipient. NASA flew Dr. Webb's Snoopy pin on Shuttle mission STS-98 in February 2001. Astronaut Scott Parazynski presented the award.

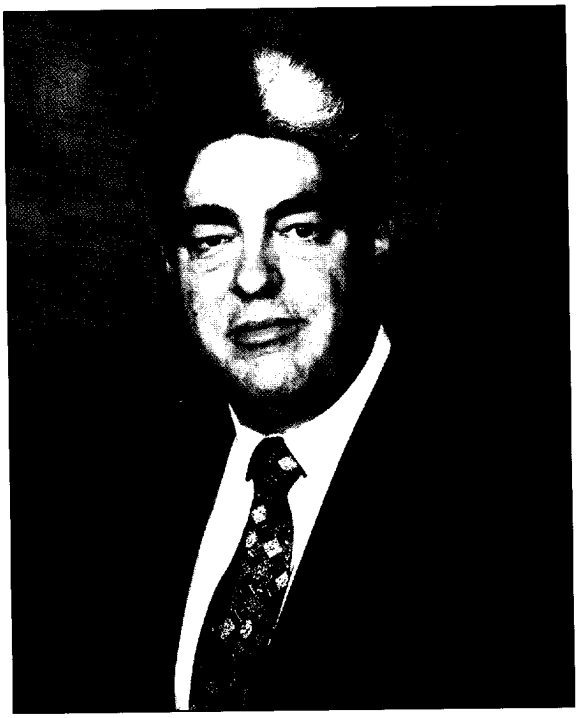
Dr. Webb obtained his PhD from the University of Washington in Seattle in 1979. He previously received the 1999 Sidney D. Leverett Environmental Science Award, the Fred A. Hitchcock Award for Excellence in Aerospace Physiology from the Aerospace Physiology Society in 1996, and the 1992 Harold V. Ellingson Literary Award from the Associate Fellows Group of the Aerospace Medical Association.

Dr. Kenneth Boff Accepts Post as Edenfield Executive in Residence at Georgia Institute of Technology

Payoff The Edenfield Executive in Residence program brings experienced successful executives to the highly regarded School of Industrial and Systems Engineering (ISyE) on campus, participating much like visiting faculty. These executives bring to a classroom setting, both graduate and undergraduate, the benefit of their work experiences in support of the ISyE curriculum.

Accomplishment Dr. Kenneth Boff, Chief Scientist, Human Effectiveness Directorate, accepted a 1-year post, part-time, with Georgia Institute of Technology in their Edenfield Executive in Residence program. Dr. Boff will help develop a vision and strategy for Georgia Tech's School of ISyE.

The vision and strategy will include interactions across Georgia Tech's six colleges—architecture, computing, engineering, Ivan Allen, management, and sciences. The overall goal of the program is to formulate a faculty recruiting plan that will enable substantial growth of ISyE's programs of research and education in human systems. This includes attracting one or more endowed chairs as well as a diversified base of funding for interdisciplinary human systems research across engineering, computing, behavioral and social sciences, and art.



Background Georgia Tech's School of ISyE offered Dr. Boff this position because of his national and international experiences in human factors. His substantial accomplishments make him a very well-qualified key contributor to Georgia Tech's effort to sustain and enhance its nationally recognized success in the increasingly important area of human systems. ISyE alumnus James C. Edenfield, President of American Software, funds this program.

Dr. Dee H. Andrews Elected a Fellow in Two Divisions of the APA

Payoff The American Psychological Association (APA) elected Dr. Dee H. Andrews, of the Human Effectiveness Directorate, as a Fellow. They based their selection on Dr. Andrews' career contributions to military training research and development, especially the directorate's work with Distributed Mission Training.

Accomplishment The APA recently elected Dr. Andrews as a Fellow in their Military Psychology Division and Applied Experimental and Engineering Psychology Division. He currently serves as division technical advisor of the directorate's Warfighter Training Research Division.

The APA recognizes Dr. Andrews' career expertise, which spans over 25 years of instructional training research, training cost-benefit analyses, and research and development management. Under Dr. Andrews' expertise and direction, the directorate received many awards, recognizing its scientific quality and positive impact on the warfighter and excellence in the aviation and space disciplines.

Among his personal achievements is the British Silver Medal, from the Royal Aeronautical Society, awarded "in recognition of his considerable contribution to research in the field of warfighter training research and systems." Dr. Andrews has authored over 60 professional publications (books, book chapters, journal articles, and technical reports) and presented at numerous international conferences.

Background Based in Washington DC, the APA is a scientific and professional organization in the United States representing psychology. With more than 155,000 members, the APA is the largest association of psychologists worldwide.

The Military Psychology Division encourages research and the application of psychological research to military problems. Members are psychologists who serve diverse functions in settings including research activities, management, teaching, consulting, work with congressional committees, and advising senior military commands.

The Applied Experimental and Engineering Psychology Division's psychologists are research scientists conducting field and laboratory research and experiments on human performance. Their role in the system design process is to ensure consideration of human psychological, physiological, and performance characteristics.

Ms. Kathleen Robinette Receives Award for Women in Government

Payoff The Award for Women in Government from *Good Housekeeping* magazine and the Center for American Women and Politics recognizes life-changing achievements made by women in government. Ms. Kathleen Robinette's work in the Civilian American and European Surface Anthropometry Resource (CAESAR) program has tremendous value for the Air Force and civilians by providing accurate three-dimensional (3-D) human models and body measurement data for the improved design of systems, equipment, and clothing.

Accomplishment Ms. Robinette, a Human Effectiveness Directorate anthropologist, recently received the Award for Women in Government from *Good Housekeeping* magazine and the Center for American Women and Politics for her work in the CAESAR program during a ceremony in Washington DC at the Library of Congress. The award recognizes Ms. Robinette's individual accomplishment and serves as a tribute to the hardworking, dedicated scientists within the directorate.

Background Ms. Robinette, Director of the directorate's Computerized Anthropometric Research and Design Laboratory, pioneered technologies, such as the first human head scanner and a whole-body scanner, that helped launch CAESAR as the first successful 3-D surface anthropometry survey. The survey obtained body measurements of 4,431 civilians, 18 to 65 years old, from the United States, The Netherlands, and Italy—countries whose populations are among the largest, tallest, and shortest in the North Atlantic Treaty Organization, respectively.

CAESAR removes the guesswork in human physical measurement with 3-D scanning. Since people are 3-D, as are the products that people use and wear, 3-D is vital in design. Traditionally, however, researchers used one-dimensional (1-D) body measurements, such as chest circumference, waist circumference, and arm length, to create 3-D human models; no other way existed to create the whole person in 3-D.

CAESAR provides over 13,000 3-D electronic human models as well as 99 traditional, 1-D body measurements. More accurate 3-D models save time and money formerly spent making 3-D models from 1-D data. With the capability to improve product designs, CAESAR allows researchers to design and tailor systems and equipment in order to accommodate different body shapes and sizes.

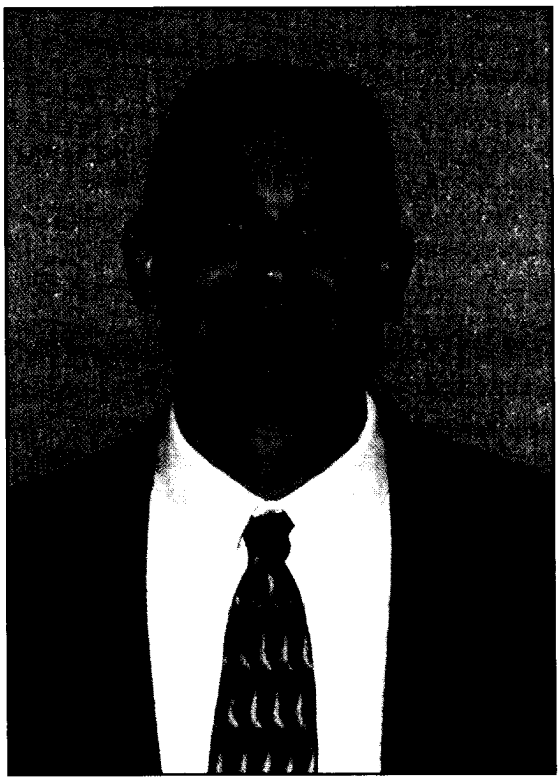
Military troops could not only share equipment more readily, but also could have customized clothing and supplies for enhanced safety and performance. Likewise, industry could use CAESAR as an effective, efficient way to design and manufacture products, such as automobiles, airplane seats, furniture, sports equipment, clothing, or artificial limbs, that better fit the variability of body shapes and sizes.

Physicist Earns American Physical Society Outstanding Achievement Medal

Payoff The American Physical Society's (APS) Division of Polymer Physics presented Dr. Timothy J. Bunning the 2001 John H. Dillon Medal for contributions to science and national security. The award also highlights the talent, dedication, and professionalism of the men and women of the Materials and Manufacturing Directorate.

Accomplishment The 40,000-member APS recognized Dr. Bunning, a polymer physicist in the directorate's Hardened Materials Branch, for helping advance materials research that benefits the warfighter, supports the development of new commercial products, and influences the study of physics. The APS awards the Dillon Medal each year to an individual within 10 years after earning a doctorate degree. The award recognizes outstanding research by polymer physicists who show exceptional promise early in their careers.

Background The APS credited Dr. Bunning with significant contributions in a variety of polymer-based optical materials areas including polymer-dispersed liquid crystals, polymeric side-chain liquid crystals, laser-resistant polymers, and active and passive polymer photonic structures. Dr. Bunning's research increased the understanding of the highly complex nature of nanoscale structure development in holographic polymer dispersed liquid crystals—polymer-based optical elements with broad-based photonic applications in a number of topical areas including display and telecommunications technology.



Before photonics became an area of opportunity, Dr. Bunning and his colleagues successfully demonstrated a one-step fabrication of electrically switchable reflection and transmission holograms using holographic photopolymerization. Working with research associates, Dr. Bunning helped unravel the complex, dynamic balance between polymerization kinetics, diffusion, and phase separation using high-resolution electron microscopy techniques, and real-time X-ray and light scattering measurements. Over the last few years, Dr. Bunning made significant contributions toward the development of comprehensive structure/property relationships for this relatively new class of materials.

Dr. Bunning's work facilitated the progression of this technology from laboratory research to intellectual property (10 patents issued/pending), to commercial implementation. Recently, Dr. Bunning extended this holographic photopolymerization technique to two photon curing systems the templating of nanoparticles in a one-step, large area process and fabrication of three-dimensional, photonic crystals with varied optical properties.

Dr. Bunning is a recipient of the 2001 Federal Laboratory Consortium Award for Excellence in Technology Transfer. In addition to APS, Dr. Bunning holds memberships in the American Chemical Society and the Materials Research Society.

Scientist Earns International Conference Lifetime Achievement Award

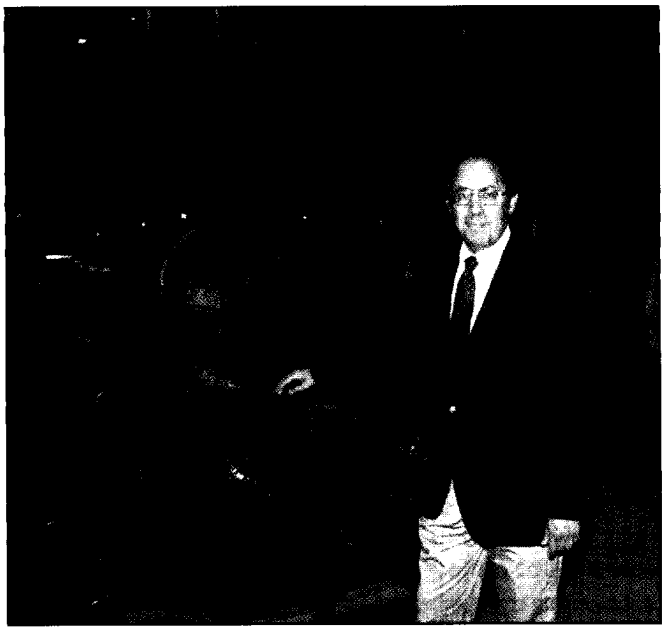
Payoff Dr. Lee Semiatin, a senior scientist in the Materials and Manufacturing Directorate's Metals, Ceramics, and Nondestructive Evaluation Division, recently received a Lifetime Achievement Award from the Thermec International Conference on Processing & Manufacturing of Advanced Materials. The Thermec International Conference presents this award every 3 years. Dr. Semiatin received the Lifetime Achievement Award for outstanding contributions in advancing the understanding of the thermomechanical processing of titanium and titanium aluminide alloys.

Accomplishment Dr. Semiatin's leadership and technical contributions led to improvements in a number of existing processes and the successful development of several new processes for high-temperature alloys. His selection for the award recognizes both individual achievement and the scientific contributions of AFRL, enhances the directorate's reputation as a world leader in materials research and development, and highlights the directorate's efforts to support Air Force operational requirements.

Background Dr. Semiatin earned his undergraduate degree in engineering mechanics from Johns Hopkins University and his master's and doctorate degrees in metallurgy and materials science from Carnegie-Mellon University. He worked for the Battelle Memorial Institute from 1978 to 1991, conducting and directing programs for a wide range of government and industry clients. A large portion of his government-sponsored work was for the Materials and Manufacturing Directorate and the Air Force Office of Scientific Research (AFOSR), including basic studies on hot working of aerospace alloys.

Dr. Semiatin joined the directorate's Metals, Ceramics, and Nondestructive Evaluation Division as a senior scientist in 1991 and was appointed research leader of the division's Processing Science Group. Under his direction, the group conducted extensive research in five principal areas: advanced metallic and intermetallic alloys; metal and ceramic matrix composites; conventional titanium, nickel, and aluminum alloys; novel processes; and the development of advanced models to describe material behavior under processing conditions.

This research resulted in the successful development of various new forging, extrusion, and rapid heat treatment processes for use in aerospace parts production. As the group research leader, Dr. Semiatin also consults regularly with manufacturers on processing concerns impacting major Air Force systems. Dr. Semiatin's research efforts over the past 25 years have substantially expanded the knowledge of not only titanium and titanium aluminide alloys, but also the processing of other difficult-to-process materials such as nickel-based superalloys and refractory alloys.



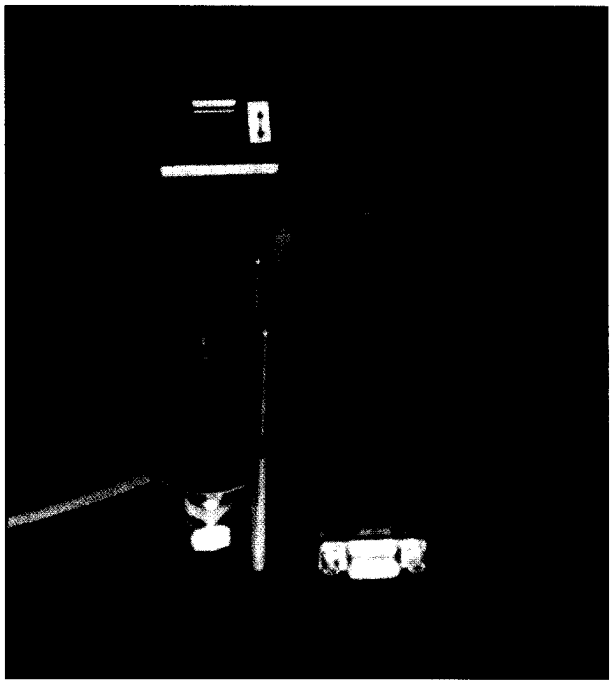
AFOSR recognized Dr. Semiatin and the Processing Science Group as a Star Team in 1992, 1995, and 2000. He received the Air Force Basic Research Award in 1995 and was elected a Fellow of the American Society for Metals International in 1992 and AFRL in 1993. Dr. Semiatin is also a member of the Minerals, Metals, and Materials Society and an honorary member of Alpha Sigma Mu.

Technology Transferred from Photosensitive Liquid Crystals Project Results in *Photonics Spectra's* Circle of Excellence Award

Payoff Materials whose optical properties change when exposed to light introduce several technology transfer opportunities that could benefit the military, industry, and the medical communities. One such opportunity resulted in this crystal-scan laser beam multimeter, selected as one of the most innovative products of the year. Optical devices, such as liquid crystal optical components, all-optical-beam quality meters, optical laser beam power meter, diffractive optical variables, and handheld nonlinear optical devices, should benefit from this technology.

Accomplishment Scientists at the Materials and Manufacturing Directorate, under a Small Business Innovation Research contract with Beam Corporation of Oviedo, Florida, developed a sensitive and highly efficient liquid crystal material that allows the manipulation of laser radiation and the characterization of laser beam shapes. Laurin Publishing's *Photonics Spectra* magazine recognized Beam Corporation's crystal-scan laser beam multimeter, which uses this material, as one of the 25 most technically innovative products of the year.

Background For the last 10 years, Dr. Thomas Cooper, a researcher with the directorate's Survivability and Sensor Materials Division, made strides towards discovering a material whose optical properties would change upon light adaptation. While working on the Photosensitive Liquid Crystals, Next Generation Materials for Dynamic Holography and Electro Optics project, researchers from the directorate and Beam Corporation researched, identified, and developed a sensitive, highly efficient liquid crystal material that allows the manipulation of laser radiation and the characterization of laser beam shapes.



The directorate transferred the technology to the Beam Corporation for use in the crystal-scan laser beam multimeter, which uses a 50-micrometer layer of nonlinear optical liquid crystal material sandwiched between two pieces of glass. The optical properties of the liquid crystal material make it sensitive to the power density of an incident laser.

When researchers place this sandwiched liquid crystal "cell" at the focal point of a laser beam, the laser forms a ring pattern. Researchers can visually observe the ring pattern on an observation screen or directly through a camera. By comparing the pattern of the beam, both with and without the cell, researchers can use computer algorithms to calculate beam profiles and information about the laser.

The *Photonics Spectra* magazine bestows the Photonics Circle of Excellence Award annually on the 25 most technically innovative new products of the year, as judged by members of the Editorial Advisory Board. For 14 years, these annual awards have recognized enterprising companies and individuals who push the limits of technology to develop new photonic products and processes.

Four Materials and Manufacturing Directorate Scientists Recognized by the Affiliate Societies Council for Outstanding Achievements

Payoff The selection of four scientists for Affiliate Societies Council (ASC) awards recognizes the high degree of dedication, professionalism, and outstanding contributions of the men and women of the Materials and Manufacturing Directorate. The combined efforts of Dr. Jata, Dr. Nicholas, Mr. Rapson, and Mr. Woody (pictured top to bottom) supported and strengthened Air Force operational requirements and helped make the nation's commercial industries more internationally competitive.

Their selection greatly enhances the directorate's reputation as a world leader in materials and manufacturing research and development for the Air Force and the nation. The recognition of these four scientists represents a total of 57 individuals in the directorate who were recognized for their contributions by the ASC over the past 40 years.

Accomplishment The ASC of Dayton, Ohio, recognized Dr. Kumar V. Jata, Dr. Theodore Nicholas, Mr. Robert L. Rapson, and Mr. William R. Woody from the directorate for outstanding achievements during their careers that helped strengthen national defense and enabled greater US global competitiveness. The ASC, comprised of representatives from about 50 engineering and science-related professional societies, has a combined membership exceeding 15,000.

Background Every year, the ASC of Dayton, Ohio, recognizes engineers and scientists from throughout the Dayton (Miami Valley) region for outstanding accomplishments in their field. Four of the 11 individuals honored in 2002 are from the directorate.

Dr. Jata is a senior engineer and technology development leader for metals in the directorate's Metals, Ceramics, and Nondestructive Evaluation Division. For nearly 30 years, he has made significant fundamental contributions to the state of art in materials science that span from ion implantation, dislocation dynamics, crack growth, and fracture and fatigue, including groundbreaking research in structure-processing-property relationship in aluminum-lithium alloys.

Dr. Nicholas is a senior scientist in the area of High Temperature Materials Life Prediction and is responsible for the directorate's status as an international center of excellence in life prediction of structural materials. He introduced new methods for dealing with material behavior under high-cycle fatigue (HCF) and significantly advanced the basic understanding of the role of prior damage in HCF of materials. HCF is the major cause of failures in Air Force turbine engines.

Mr. Rapson is chief of the Nonmetallic Materials Division, where he leads more than 100 military and civilian scientists, engineers, and staff and provides technical direction for over $100M per year of research programs. He is the Air Force lead on the Department of Defense (DoD) Reliance Materials and Processes (M&P) Panel that advocates and plans the course of DoD-wide research and development for M&P.

Mr. Woody is chief of the Survivability and Sensor Materials Division and has a current staff of over 70 government employees and 85 on-site contractors, visiting scientists, and students with an annual budget in excess of $50M. He is the nation's foremost expert on laser hardening.

Dr. Claudia Kropas-Hughes Selected for American Society of Nondestructive Testing Fellow Award

Payoff Dr. Claudia Kropas-Hughes' leadership and technical contributions resulted in significant improvements in a number of existing nondestructive evaluation (NDE) techniques, and she developed new processes for nondestructive testing and pattern recognition. Her selection as American Society of Nondestructive Testing (ASNT) Fellow recognizes her individual achievement and the scientific contributions of Materials and Manufacturing Directorate researchers. It also enhances the directorate's reputation as a world leader in materials and manufacturing testing-related research and development, and highlights the directorate's efforts to support Air Force operational requirements.

Accomplishment ASNT selected a directorate scientist as a Fellow for her outstanding contributions to the advancement and understanding of nondestructive material testing and evaluation. Dr. Kropas-Hughes, a scientist in the Metals, Ceramics, and Nondestructive Evaluation Division, was one of only five candidates selected from the nearly 10,000-member society to receive the award for 2002. ASNT will present the award during the ASNT Annual Fall Conference in San Diego, California, in November 2002.

Background Dr. Kropas-Hughes earned one undergraduate degree in applied mathematics from the Florida Institute of Technology, another undergraduate degree in electrical engineering from the University of Dayton, and her master's degree in electrical engineering from California State University. She was the first woman student participating in the Dayton Area Graduate Studies Institute program to receive her doctorate, which was also in electrical engineering-pattern recognition, from the Air Force Institute of Technology. Dr. Kropas-Hughes joined the directorate in 1989 to perform research and development of ultrasonic, NDE, and X-ray computed tomography (CT) techniques.

In her current position as the directorate's Nondestructive Evaluation Research Leader, Dr. Kropas-Hughes leads a team of 11 professionals in the research and development of NDE techniques and methods using ultrasonics, electromagnetic and optical methods, X-ray CT and computational methods for signal analysis, modeling, and optimization. In addition, Dr. Kropas-Hughes was part of an Electronic Prototyping Research Team, recognized as an Air Force Office of Scientific Research "Star Team." Electronic prototyping provides the means by which a researcher can conduct normally time-consuming and costly material research in a virtual environment.

Dr. Kropas-Hughes is a member of the American Society for Testing and Materials and is a senior member of the Society of Women Engineers and the Institute for Electrical and Electronic Engineers. She currently serves as the Vice Chairman of the Miami Valley Section of ASNT. The results of her nondestructive evaluation and pattern recognition work were published in 21 professional journals and publications including *Materials Evaluation, Pattern Analysis and Applications*, *Review of Progress in Quantitative Nondestructive Evaluation*, and *Engineering Applications for Artificial Intelligence*.

Materials Scientist Honored by National Academy of Sciences of Ukraine

Payoff Over a career spanning more than 25 years, Dr. Lee Semiatin's research led to the successful development of new forging, extrusion, and rapid heat treatment processes, many of which are used today in aviation and aerospace parts production, as well as significant improvements in many existing processes. His pioneering efforts also expanded the knowledge base of not only titanium and titanium aluminide alloys, but also several other difficult-to-process materials such as nickel-base superalloys and refractory alloys.

His selection for the honorary degree recognizes both individual achievement and the scientific contributions of the Air Force Research Laboratory. It enhances the Materials and Manufacturing Directorate's reputation as a world leader in materials research and development.

Accomplishment The National Academy of Sciences of Ukraine recognized Dr. Semiatin of the directorate's Metals, Ceramics, and Nondestructive Evaluation Division, for contributions in the processing of conventional and advanced alloys. The academy's G.V. Kurdyumov Institute for Metal Physics presented Dr. Semiatin with an honorary doctor of science degree during a special ceremony in Kiev. He is only the fifth person in 5 years to receive the honor.

Background Dr. Semiatin earned his undergraduate degree in engineering mechanics at Johns Hopkins University and his master's and doctorate degrees in metallurgy and materials science at Carnegie-Mellon University. He worked for the Battelle Memorial Institute from 1978 to 1991. Much of his research there, including his basic studies on hot working of aerospace alloys, supported the directorate and the Air Force Office of Scientific Research (AFOSR). These contributions also helped earn him the National Aerospace Plane Titanium Aluminide Achievement Award in 1989.

Since joining the directorate in 1991, Dr. Semiatin's leadership and technical contributions earned him several high-level awards including the organization's Charles J. Cleary Scientific Achievement Award, the Air Force Basic Research Award, and an Air Force Scientific Achievement Award. For more than a decade, he has led the research effort in five principal areas including advanced metallic and intermetallic alloys; metal and ceramic matrix composites; conventional titanium, nickel, and aluminum alloys; novel processes; and the development of advanced models to describe material behavior under processing conditions.

AFOSR recognized Dr. Semiatin and the Processing Science Group he oversees as an AFOSR Star Team in 1992, 1995, 2000, and 2002. He received the Air Force Basic Research Award in 1995 and was elected a Fellow of ASM International in 1992 and the Air Force Research Laboratory in 1993. Dr. Semiatin is also a member of the Minerals, Metals, and Materials Society and an honorary member of Alpha Sigma Mu. He is an adjunct professor in the Industrial, Welding, and Systems Engineering Department at the Ohio State University and the Materials Program at the University of Dayton.

Mr. Alan Fletcher Receives DoD's 2001 DSP Distinguished Achievement Award

Payoff Mr. Alan J. Fletcher, a materials engineer with the Materials and Manufacturing Directorate, led a Department of Defense (DoD)-wide effort to enhance the production quality of sealants and seals used to build and maintain combat aircraft and other flight systems, while lowering associated quality control and assurance costs. In one case, product returns decreased by nearly 90%. Eliminating laboratory testing saved an estimated $200,000 to $350,000 annually, while price reductions for the most common fuel tank sealant saved $2.2 million.

Accomplishment Mr. Alan J. Fletcher, a materials engineer with the directorate's Systems Support Division, received the 2001 Defense Standardization Program (DSP) Distinguished Achievement Award as well as the program's top prize monetary award of $5,000 for outstanding contributions.

Background Mr. Fletcher is an internationally acknowledged expert in sealants and aerospace elastomeric seals. He served multiple terms as the chairman of the Non-Government Standards' Society of Automotive Engineers (SAE) and Performance Review Institute (PRI) Committees on sealants and elastomers for more than a decade and is responsible for preparing replacement specifications.

Mr. Fletcher reasoned that the use of government quality products lists (QPLs) within the non-government sector might pay dividends similar to those realized by a robust DoD QPL program. He worked with SAE and PRI to develop a consensus industry standards' QPL program to replace the military specifications and government QPL system.

In conjunction with this effort, Mr. Fletcher assumed an instrumental role in the development of the National Defense Contractor Accreditation Program (NADCAP) that is used successfully in sealant and elastomer specifications to evaluate quality systems for suppliers and distributors. Under NADCAP, the number of product returns decreased by almost 90%.

Mr. Fletcher's efforts eliminated standardization funding associated with the preparation and maintenance of military specifications and QPLs for seven military specifications and seven QPLs. Twelve other conversions, currently in progress, are expected to yield an annual savings of $760,000 to the government. Another outcome is the elimination of sealant and seals' laboratory testing, which saved $200,000 to $350,000 annually.

In the case of industry, the price of a 6-ounce tube of the most common fuel tank sealant dropped from $10.15 to $7.55, more than a 25% reduction, resulting in an annual savings of $2.2 million to industry. Mr. Fletcher's efforts also brought about incalculable savings for the military branches and industry because of significant reductions in the number of field failures and leaks.

Dr. John Maguire Honored as SME Fellow

Payoff Selection as a Society of Manufacturing Engineers (SME) Fellow is a highly sought and prestigious honor given to leaders who have made outstanding contributions to the manufacturing profession. The award recognizes individuals who have made clear, recognized, and respected contributions to the field of manufacturing.

The SME selected Dr. John Maguire, a research leader and principal engineer for the Materials and Manufacturing Directorate, as a Fellow in 2002. Dr. Maguire's selection and outstanding efforts are testimony to the high degree of dedication and professionalism of the men and women of the directorate.

Accomplishment The SME selected Dr. Maguire as a Fellow for his outstanding contributions to the field of manufacturing. He is widely respected and recognized for contributions to the areas of computer modeling and simulation, namely the field of artificial intelligence and neural networks, and intelligent processing and manufacturing of materials.

Background In his current position as a materials research leader and principal engineer for the directorate's Manufacturing Technology Division, Materials Process Design Branch, Dr. Maguire contributed to soft and interfacial matter research. He also contributed to the field of material processing and developed new techniques in computer simulation and molecular dynamics.

Advanced future material applications, such as high-power radars, ultra lightweight airframe structures, and large adaptive optics, require the development of new materials whose characteristics far exceed the capabilities of current materials. Dr. Maguire's discoveries in the areas of soft, interfacial, granular, and nanomaterials could provide new forms of matter with engineered properties and controlled structures.

Dr. Maguire was part of an Electronic Prototyping Research Team recognized as an Air Force Office of Scientific Research "Star Team" for the 2-year period of 2000 and 2001. Electronic prototyping provides the means by which a researcher can conduct materials research, which is normally time-consuming and costly, in a virtual environment.

In 2001, Dr. Maguire received the Dr. J. Keith Brimacombe Award from the Intelligent Processing and Manufacturing Materials Conference, an international community of people interested in intelligent software and hardware applications. During his career, Dr. Maguire published the results of his materials processing and manufacturing work in a wide range of scientific and technical literature.

Captain James P. Lake Receives Air Force Research and Development Award

Payoff Captain James P. Lake of the Propulsion Directorate, received the US Air Force Research and Development Award. He received this prestigious award based on his groundbreaking work with solid rocket motors and electrical propulsion systems for spacecraft.

Accomplishment Capt Lake coinvented the world's first completely controllable solid rocket propellant. Solid rocket motors using this propellant can perform multiple start/stop/restart operations and produce varying levels of thrust. He also created fully automated spacecraft thruster test facilities for the High Power Hall thruster life test and the micro-pulsed plasma thruster (PPT) for the Technology Satellite 21.

Capt Lake's automated system records all performance and environmental data, calibrates the thrust stand, and executes emergency shutdown procedures without human intervention. His modifications for the micro-PPT testing now provide a three order-of-magnitude sensitivity increase in thrust measurement. The directorate saved over $1 million after applying these innovations to these two programs.

Background Capt Lake's solid rocket motor provides controllable performance like that of a liquid rocket engine in a much simpler design and provides future Air Force spacecraft with more options for high thrust and reliable operation. Future missions, such as on-orbit servicing and next-generation kinetic energy interceptors, are active candidates for this first-of-a-kind solid rocket propellant.

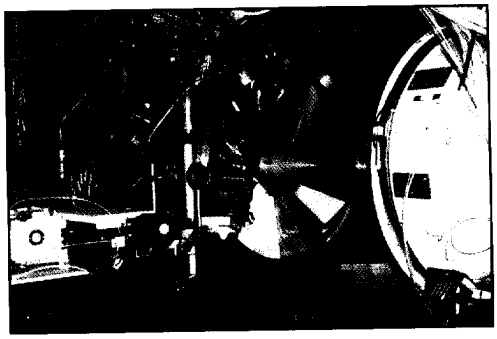
Engineers design electric propulsion systems for spacecraft to fire for prolonged periods and they test them for long periods. The High Power Hall thruster test requires 7,200 hours to simulate a full space mission. This originally required human operators to monitor the thruster continuously 24 hours a day. Capt Lake's new control system eliminated the need for 24-hour monitoring and supervision, and replaced the test operators with automated software capable of making important decisions autonomously.

Micro-PPT spacecraft engines produce thrust levels in the micro-pound range, but operate continuously for an extended period. Accurate measurements during testing allow significantly enhanced precision in the calibration of these thrusters. Future generations of Air Force microsatellites could benefit from this advancement in thrust measurement.

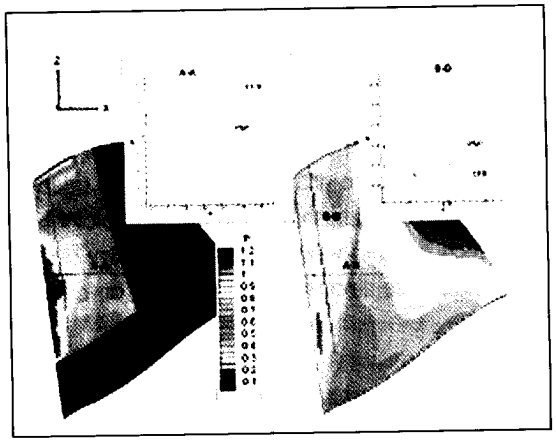
Small Business Partner Wins Governor's Emerging Technology Award

Payoff The State of Ohio awarded a Governor's Emerging Technology Award to Innovative Scientific Solutions, Inc. (ISSI), a small business working with the Propulsion and Air Vehicles Directorates' pressure sensitive paint (PSP) technology development program. Their significant development will lead to far less costly data collection of pressure points on aerodynamic bodies in both high- and low-speed and pressure applications. Both government and commercial enterprises will benefit from this achievement.

Accomplishment The government and small business partnership developed a PSP that was far less sensitive to temperature changes and extended the applicable speed range of the new measurement technique. Under this program, researchers obtained pressure data from an aerodynamic body at a record-breaking low speed of 27 miles per hour (mph). This program also leads the field in the development of PSP technology for applications in rotating machinery.



Background PSP is a micro-porous paint that changes luminescent intensity as a function of the pressure. With PSP, an aerodynamicist can obtain a visual, global pressure map of the surface without disturbing the flow field or adding costly/time-consuming instrumentation.



Prior to this accomplishment, PSP had several deficiencies, such as a signal-to-noise limitation that restricted the ability of PSP in applications with very low speeds, and in high-pressure applications such as turbomachinery. Also, the sensitivity of PSP to temperature contributed to unacceptably high errors in the pressure data.

The newly developed PSPs drastically improved signal-to-noise and reduced temperature sensitivity, increasing the range of applications of this new technology. To accomplish this, the ISSI/AFRL partnership developed an entirely new PSP system based on fluorinated polymer chemistry, new paint method applications, ultra stable light sources, and scientific-grade imaging systems for obtaining the raw pressure data.

The new paint formulation and improved data acquisition system adequately resolve pressure fields from aerodynamic bodies performing at speeds as low as 27 mph, making the system a valuable tool for automotive/general transportation applications. The technique can also acquire surface pressure data from a state-of-the-art transonic turbomachine. ISSI engineers also developed new software to graphically display the raw intensity data, convert the intensity data into pressure, and transfer the quantitative pressure map onto a three-dimensional mesh representative of the aerodynamic body.

Propulsion Directorate Manager Chosen as *Aviation Week* Laureate

Payoff The February 4, 2002 issue of *Aviation Week and Space Technology* announced Mr. Robert A. Mercier, of the Propulsion Directorate's Aerospace Propulsion Office, as a laureate recipient for the magazine's 45th Annual Aerospace Laurels selections.

Accomplishment The magazine staff chose Mr. Mercier, Deputy for Technology for the Aerospace Propulsion Office, as a 2001 Laureate in the Aeronautics/Propulsion category. This award honors individuals and teams who made significant contributions to the global field of aerospace during 2001.

Mr. Mercier earned this recognition for his role in the successful demonstration of a hydrocarbon-fueled scramjet engine known as the Performance Test Engine (PTE). The PTE is a heavyweight, demonstrator engine developed by Pratt & Whitney for the directorate's Hypersonic Technology (HyTech) program. The HyTech Team completed the free jet testing of the PTE in January 2001.

Team members receiving the award are Mr. Robert Faulkner, Mr. Joaquin Castro, and Mr. Curtis Berger of Pratt & Whitney Space Propulsion. The magazine will present the laureate trophy at a ceremony held at the National Air and Space Museum.

Background The HyTech program is the latest in a long series of Air Force efforts to prove the viability and utility of the supersonic combustion ramjet engine. The objective of the HyTech program is to establish a scramjet technology base with near-term applications to hypersonic cruise missiles. Once in place, the HyTech Team can expand this technology base to include propulsion systems for reusable hypersonic vehicles such as strike/reconnaissance aircraft and affordable, on-demand access to space.

Following the success of the PTE and using a building block approach, the HyTech Team will test a Ground Demonstrator Engine (GDE). The GDE has the same flowpath as the PTE but differs in materials and fuel system components.

The team plans two versions of the GDE. The first version will demonstrate fuel cooling of the engine, which is made of flight-like engine materials, while the second version includes a flight-weight fuel system and a closed-loop engine controller.

Dr. Alan Garscadden Named AIAA Fellow

Payoff The American Institute of Aeronautics and Astronautics (AIAA) is the world's largest professional society devoted to the progress of engineering and science in aviation, space, and defense. The AIAA honors Fellows for making notable contributions to the arts, sciences, or technology of aeronautics or astronautics.

Accomplishment The AIAA recently named Dr. Alan Garscadden, Chief Scientist in the Propulsion Directorate, a Fellow for 2002. Since the AIAA elects only one Fellow each year for every 1,000 voting members of AIAA, Fellows are part of a select group.

Background Dr. Garscadden serves as technical adviser on a wide spectrum of aeronautical research including many facets of propulsion, aerospace power, hypersonics, laser physics, combustion, and plasma phenomena and applications. He is known for his work in theoretical and experimental research in plasmas and energized gas flows, lasers, laser-based measurements, plasma-processing of thin films, optical and mass spectroscopic measurements, electron impact cross sections and their influence on electron transport, and the derivation of collision cross sections from transport data.

Dr. Garscadden authored more than 250 publications and presentations and served on many organizing committees for both national and international meetings and symposiums. He has served on technical committees and in professional societies, authored several book chapters, and conducted approximately 120 invited lectures and presentations to peer audiences. He has also served as thesis adviser and adjunct professor for several local, national, and foreign universities.

Mr. Mark A. Wunderlich Receives the Association of Old Crows Research and Development Award

Payoff Mr. Mark A. Wunderlich of the Sensors Directorate's Electro-Optics Warfare Division received the International Defense Electronics Association of Old Crows Research and Development Award. Mr. Wunderlich received this award for his significant contributions toward the development and demonstration of closed-loop infrared countermeasures as part of the Laser Infrared Flyout Experiment (LIFE) program.

Accomplishment As LIFE program manager, Mr. Wunderlich was responsible for the programmatic aspects of LIFE as well as the oversight of the entire program. Mr. Wunderlich solved a number of technical challenges prior to the closed-loop infrared countermeasures demonstration.

He led the LIFE program in two successful live-fire demonstrations of the closed-loop infrared countermeasure system. These demonstrations showed the full closed-loop infrared countermeasures process from missile warning to countermeasure effectiveness assessment. They also showed the potential for affordability improvements.

Background Mr. Wunderlich guided progress reviews and working groups to address challenges. Composed of more than 20 government and industry people, Mr. Wunderlich led the LIFE Team through a thorough analysis of the technical status and test readiness of every major component, implementing corrective action. Mr. Wunderlich evaluated all subsystems prior to testing, both at the contractor's facility and in hardware-in-the-loop tests conducted at the Guided Weapons Evaluation Facility, Eglin AFB, Florida.

Mr. William Baldygo, Jr. Receives Mohawk Valley Accent on Excellence Award

Payoff Mr. William Baldygo, Jr., of the Sensors Directorate's Radar Signal Processing Branch, received the Mohawk Valley Accent on Excellence Award for his work in the Rome, New York community. *Northland Communications* and the *Utica Observer-Dispatch* sponsor the Accent on Excellence Award to showcase community achievements of the region's leaders who are younger than 40.

Accomplishment *Northland Communications* and the *Utica Observer-Dispatch* recognized Mr. Baldygo for his contributions in Rome, New York. He continues to volunteer his time to make the community a better place to raise families, find career satisfaction, and enjoy prosperity.

Background *Northland Communications* and the *Utica Observer-Dispatch* officials offer this award to people younger than 40 who are making a difference and inspiring others to remain in the area and do the same. Accent on Excellence celebrates the accomplishments of people living in the Mohawk Valley of New York.

Mr. Baldygo began to mentor other staff members at the directorate shortly after his third year of civilian service, helping scientists and engineers in industry, academia, and government to become solid contributors. The most significant community service performed by Mr. Baldygo is through his professional affiliation with the Institute of Electrical and Electronics Engineers (IEEE).

Mr. Baldygo is chairman of the IEEE Mohawk Valley Section. The IEEE is a non-profit group dedicated to educating people on advances in the science and technologies of engineering and computers. Members of the group reach out to the community, especially to high school and college students. Mr. Baldygo serves as lector at St. Joseph's Roman Catholic Church in Lee Center and is an assistant T-ball coach in Lee Center.

Mr. John Turtle Receives the General Ronald W. Yates Award for Excellence in Technology Transfer

Payoff The Air Force Materiel Command recognized Mr. John Turtle for his technical leadership in developing phased array antenna technology. Low profile, phased array antennas have important applications to low-observable and high-performance Department of Defense (DoD) platforms and to commercial aircraft where fuel economy is essential. Major commercial carriers have fully embraced this major technology breakthrough in order to provide passengers with Internet access.

Accomplishment Mr. John Turtle, of the Sensors Directorate's Antenna Technology Branch, received the General Ronald W. Yates Award for Excellence in Technology Transfer. A recent letter from Boeing officials clearly credits Mr. Turtle with leading the development of this technology.

Background Using technology development that was started in the 1980s by the Antenna Technology Branch, Boeing is currently applying active phased array antennas to both DoD and commercial satellite communications. This technology had its origins in the Integrated Circuit Airborne Phased Array contract with Boeing, which researchers trace back to Mr. Turtle's research efforts.

For the past 10 years, Mr. Turtle served as laboratory program manager for projects that included multiple simultaneous contracts, in-house antenna element modeling, and installation of test equipment at the branch's antenna range to make the first measurement of the gain of an active aperture phased array antenna. He managed a technical team that interacted with contractors to provide radio frequency component designs, antenna architecture studies, radiating element improvement, and multilayer microwave packaging.

From the late 1980s, Mr. Turtle was responsible for developing new phased array antennas for satellite communication applications. Due to his efforts, the directorate's antenna laboratory enjoys a full complement of state-of-the-art measurement equipment.

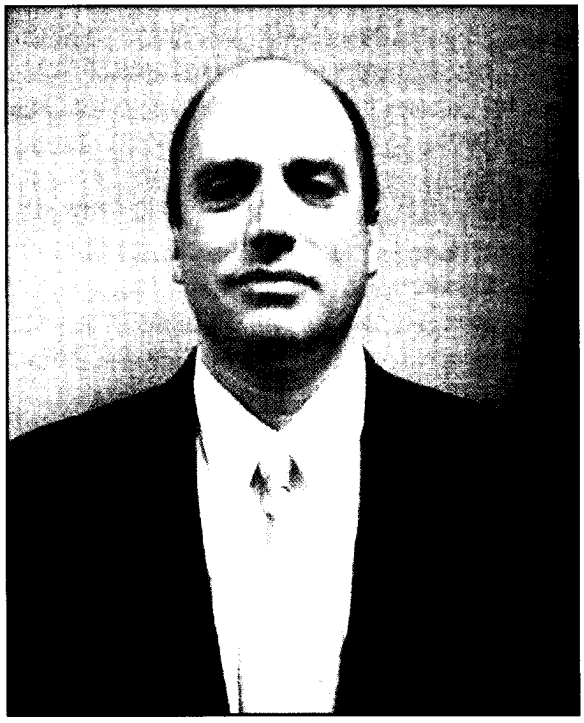
To market this new technology, Mr. Turtle teamed with Boeing and the National Aeronautics and Space Administration to participate in the Joint Warrior Interoperability Demonstrations and the Expeditionary Force Experiments. These demonstrations clearly showed the important application of phased array antennas for both DoD and commercial satellite communications.

The Federal Communications Commission licensed Boeing to provide high-speed Internet access to commercial airline passengers using phased array antennas. In 2002, Lufthansa Airlines plans to equip its long-haul fleet with these new phased array antennas.

Mr. John Stovall Honored with Professionalism in Contracting Award

Payoff Mr. John Stovall, of the Sensors Directorate Contracting Division, recently won the Secretary of the Air Force Professionalism in Contracting Award. Mr. Stovall won high praise from management, peers, and customers as well as the nomination from both divisions he supports.

Accomplishment Mr. Stovall expertly managed 412 ongoing contracts valued at over $690 million, while resolving complex administrative issues and guiding several high interest programs to timely contract award. He performed high-quality contracting officer review of over 200 contract actions.



The directorate hand selected Mr. Stovall to lead the Targets Under Trees $45 million acquisition, identified by senior Air Force leadership as one of the most critical new programs. He expertly led the acquisition strategic development and resolved many complex managerial and technical issues that threatened successful program execution.

A lead-contracting officer for the AFRL award-winning Moving Target Feature Phenomenology for Track Maintenance Team, Mr. Stovall oversaw the funding of seven contract awards for over $7 million to support a high priority moving target tracking program at the Defense Advanced Research Projects Agency (DARPA). Mr. Stovall received a letter of appreciation from the Sensors technical director for his efforts, and lab management credited him for prompting DARPA to offer additional funding, contingent upon the directorate keeping him as the contracting officer for the new program.

Background The Air Force Materiel Command (AFMC) Contracting Division requested that Mr. Stovall participate in an Air Force-wide evaluation of the Standard Procurement System because of his reputation and demonstrated knowledge. Mr. Stovall refined and executed the Aeronautical Systems Center (ASC) Workload Assessment Model to gauge workload of over 400 employees in management to assign matrixed contracting workforce for the ASC's contracting office.

He currently serves as the National Contract Management Association Vice President for Membership in the local chapter. He displayed his superior team leadership skills on the AFMC award-winning Strategic Acquisition Award Team. AFMC recognized this team for developing and creating a fully electronic, user-friendly unliquidated obligations and contract closeout tracking technique for the Air Force, Army, Navy, Defense Logistics Agency, and other Department of Defense funds at risk of expiration.

Air Force Research Laboratory|AFRL

Science and Technology for Tomorrow's Air and Space Force

Success Story

AFRL TECHNOLOGY ENHANCES LOGISTICS SITUATION AWARENESS

The Human Effectiveness Directorate's Deployment and Sustainment Division recently conducted a field evaluation of Logistics Control and Information Support (LOCIS) Spiral 1 and Spiral 2 technologies with the 16th Special Operations Wing at Hurlburt Field, Florida. This evaluation demonstrated dramatically increased situation awareness of mission resources through advanced visualization techniques, data fusion, customizable user interfaces, and threshold monitoring and reporting.

Air Force Research Laboratory
Wright-Patterson AFB OH

Accomplishment

The directorate's LOCIS research team conducted three preliminary field evaluations and a final evaluation, analyzed the data, and reported their findings. Personnel at Hurlburt Field widely accepted the LOCIS capabilities and used them daily to support deployment and sustainment of Operation ENDURING FREEDOM.

The LOCIS informational views provide a quick look of wing capability to senior decision makers and are used in lieu of briefing charts for maintenance stand-up meetings. This saves time searching for and assembling data into stand-up reports.

Background

LOCIS is a 4-year proof-of-concept. The directorate's Logistics Readiness Branch developed the program, and the Agile Combat Support Division of the Air Force Command and Control Intelligence, Surveillance, and Reconnaissance Center at Langley Air Force Base, Virginia officially sponsored the program.

LOCIS focuses on wing-level command and control for logistics. The program is researching and developing information technologies that will enhance the ability of the logistics community to effectively manage mission resources and assimilate logistics information for decision making in an Expeditionary Air Force/Agile Combat Support Command and Control environment.

The LOCIS effort consists of three yearly spirals, culminating in annual demonstrations where the team collects user feedback for the next spiral. The LOCIS field evaluation provided valuable warfighter feedback for improving LOCIS tools and created strong program advocates that are leading technology transition activities.

Human Effectiveness
Support to the Warfighter

Additional information

To receive more information about this or other activities in the Air Force Research Laboratory, contact TECH CONNECT, AFRL/XPTC, (800) 203-6451 and you will be directed to the appropriate laboratory expert. (03-HE-01)

Air Force Research Laboratory|AFRL

Science and Technology for Tomorrow's Air and Space Force

Success Story

CREW FATIGUE QUANTIFIED DURING ENDURING FREEDOM AIRLIFT MISSIONS

Human Effectiveness Directorate scientists and engineers (S&Es), in conjunction with Air Force Operational Test and Evaluation Center (AFOTEC) personnel, conducted an objective wartime aircrew fatigue assessment during C-17 missions to Afghanistan. Directorate S&Es expect the results of this assessment to lead to decreases in the approximately $54M in personnel, aircraft, and property lost each year in Air Force Class A mishaps related to warfighter fatigue.

Air Force Research Laboratory
Wright-Patterson AFB OH

Accomplishment

As an integral part of the Air Mobility Command's (AMC) Counter Fatigue program, S&Es from the directorate's Warfighter Fatigue Countermeasures program, at Brooks City Base, Texas, and AFOTEC, Det. 1, at Kirtland Air Force Base, New Mexico, conducted an objective wartime aircrew fatigue assessment during the round-trip C-17 missions supporting Operation ENDURING FREEDOM. These extended 22+ hour missions, with crews deployed from the continental United States, included multiple aerial refuelings.

This effort will provide a baseline for development of the AMC fatigue management policy. Data will also support the ongoing operational validation of the Sleep, Activity, Fatigue, and Task Effectiveness (SAFTE®) model that quantitatively predicts fatigue effects on human performance.

Background

Data collection during the C-17 flights included the use of psychomotor tests, activity monitors, activity logbooks, and subjective fatigue self-assessments. Part of the analysis will include a comparison of actual aircrew work and sleep performance with predicted cognitive effectiveness ratings generated by the Fatigue Avoidance Scheduling Tool (FAST™).

The FAST software interface generates cognitive effectiveness predictions over time based on the SAFTE model. The SAFTE model is a homeostatic representation of the three-process, biological mechanisms that affect cognitive and physiological capability in humans. The model is the product of over 12 years of extensive model development and comparisons of the model's algorithms to laboratory data collected over the past 20 years.

Problems associated with human fatigue are not limited to military operations. Air Force fatigue countermeasures research products also have direct application to over 20 million Americans who perform shift work and to millions who experience the adverse effects of jet lag or even a night of disrupted sleep.

Human Effectiveness
Support to the Warfighter

Additional information

To receive more information about this or other activities in the Air Force Research Laboratory, contact TECH CONNECT, AFRL/XPTC, (800) 203-6451 and you will be directed to the appropriate laboratory expert. (03-HE-02)

Air Force Research Laboratory|AFRL

Science and Technology for Tomorrow's Air and Space Force

Success Story

SPATIAL AUDIO TECHNOLOGY REDUCES RISK FOR AWACS TRANSITION

The Human Effectiveness Directorate developed and transitioned its spatial audio knowledge and software, which dramatically improves an operators' ability to discriminate among multiple communication channels. This software directly reduces risk for the Airborne Warning And Control System (AWACS) Block 40/45 fleet upgrade by demonstrating a communications system with many of the same attributes as those desired for the airborne platform. Among those who will use the system at Nellis Air Force Base (AFB), Nevada, are operators from the United States Air Force (USAF) Weapons School and the Combined Air Operations Center supporting the Joint Expeditionary Force Experiment.

Air Force Research Laboratory
Wright-Patterson AFB OH

Accomplishment

The directorate collaborated with Compunetix, Inc., the Pittsburgh, Pennsylvania vendor selected to upgrade the communication system at the USAF Weapons School, to transition the spatial audio capability into Compunetix's hardware and software architecture. The 98th Operation Support Squadron at Nellis AFB, Nevada, selected Compunetix to provide a system nearly identical to the system previously installed at the Pacific Missile Range Facility, Barking Sands, Kauai, Hawaii.

The USAF Weapons School Command and Control Operations Division at Nellis AFB is the premier site for air battle management tactics instruction. This location will be optimal for showcasing the new capability to the entire command and control (C2) community.

Background

AWACS controllers typically communicate in noisy acoustic environments during mission operations that exceed 20 hrs in duration. Battle managers routinely monitor up to five external and four internal communications ports (radios and intercom channels), discriminating which port was active by a combination of voice recognition and volume setting. The spatial audio technology gives the listener the impression that the voices on the different channels are coming from different directions with respect to his/her location.

With a spatial audio addition, operators experience intelligibility increases of 15-30% when azimuth separates the audio channels as well as the ability to discriminate between multiple simultaneous radio/intercom communications. The directorate initiated the Virtual Air Commanders program to transition technologies that specifically benefit the airborne C2 operator's system interface. Spatial audio is one of the technologies specifically examined and tailored to that interface.

Human Effectiveness
Support to the Warfighter

Additional information

To receive more information about this or other activities in the Air Force Research Laboratory, contact TECH CONNECT, AFRL/XPTC, (800) 203-6451 and you will be directed to the appropriate laboratory expert. (03-HE-03)

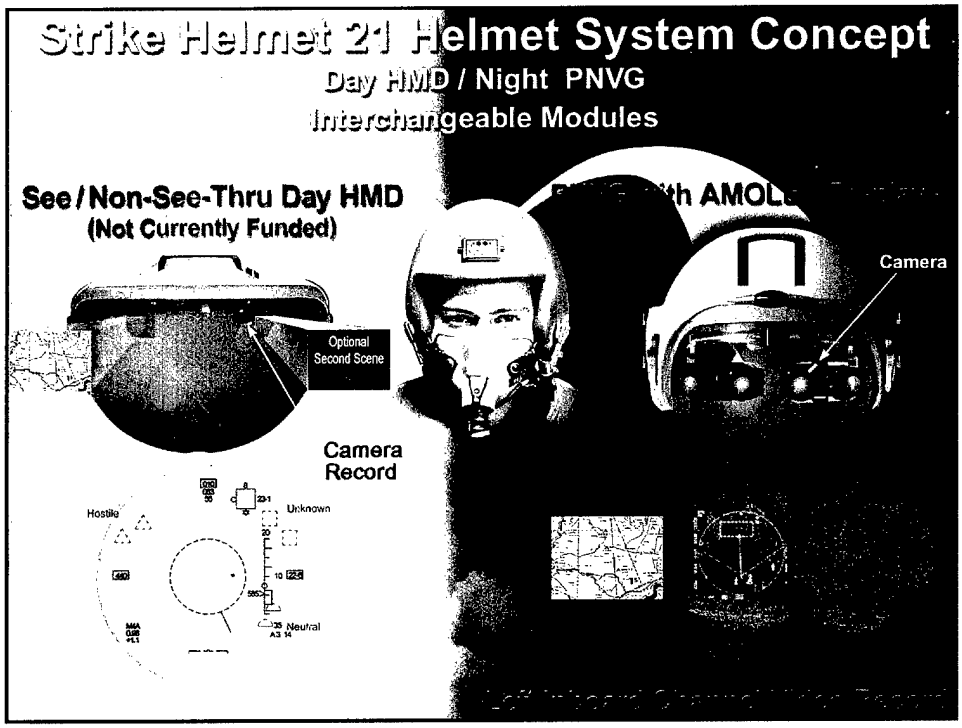
Air Force

Air Force Research Laboratory|AFRL

Science and Technology for Tomorrow's Air and Space Force

Success Story

NEW MICRODISPLAY TRANSITIONS TO USAF AND INDUSTRY



The Human Effectiveness Directorate transitioned a new type of microdisplay, ideally suited for use in helmet-mounted displays (HMDs), into the US Air Force Strike Helmet 21, Panoramic Night-Vision Goggle (PNVG), and Digital Knee Board programs as well as industry.

Air Force Research Laboratory
Wright-Patterson AFB OH

Accomplishment

Current airborne military HMDs use miniature cathode-ray tubes (CRTs) to produce the images the pilot sees. These CRTs have drawbacks however. They are bulky, do not emit light efficiently, cannot easily produce color, and require potentially hazardous high voltages.

The directorate created a microdisplay technology that overcomes these issues. Termed active-matrix organic light-emitting diodes (AMOLEDs), these new displays are small, thin, lightweight, low-voltage, low power, and completely self-contained with their own video controller.

AMOLED manufacturers use the same techniques as those used to make semiconductors, so they produce displays in one continuous, economical process. AMOLEDs occupy minimal space and can run on battery power, maintain visibility in bright environments, and emit the same range of colors as a desktop CRT.

Background

The directorate produced AMOLEDs through Phase III Small Business Innovation Research and Dual-Use Science and Technology programs. According to one estimate, more than 100 companies are pursuing this technology. Since the transition of AMOLED technology to the US Air Force, the US Army, and commercial contractors, far-reaching benefits are possible such as wide field-of-view PNVGs, high-definition television, three-dimensional game systems, and digital video disc players.

Human Effectiveness
Support to the Warfighter

Additional information

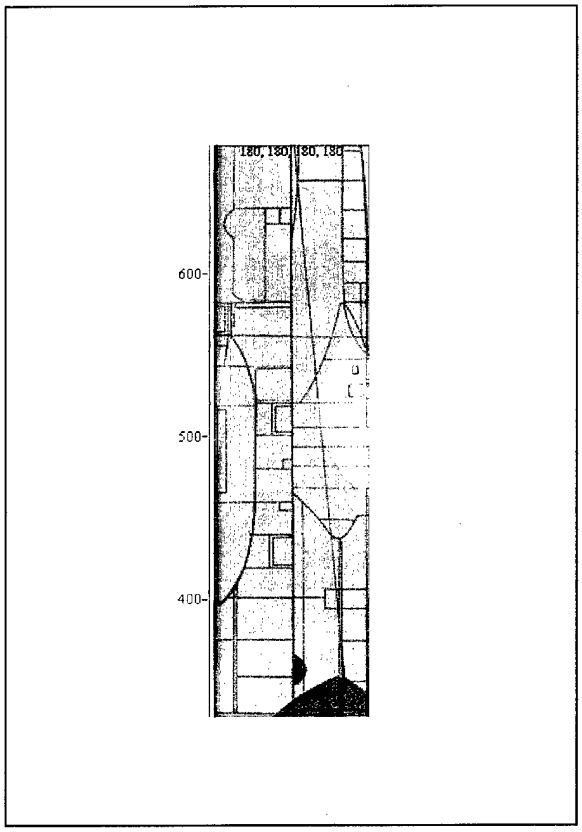
To receive more information about this or other activities in the Air Force Research Laboratory, contact TECH CONNECT, AFRL/XPTC, (800) 203-6451 and you will be directed to the appropriate laboratory expert. (03-HE-06)

Air Force Research Laboratory|AFRL

Science and Technology for Tomorrow's Air and Space Force

Success Story

ACTIVE SYNCHROPHASER LOWERS C-130 INTERIOR NOISE LEVELS



The Human Effectiveness Directorate's Crew System Interface Division completed flight tests and analyses of the C-130 Active Synchrophaser System, which showed reduced interior noise levels by as much as 22 decibels (dB). Now for the first time, the directorate demonstrated reduced noise levels in four-engine propeller aircraft using a propeller synchronization technique.

Air Force Research Laboratory
Wright-Patterson AFB OH

Accomplishment

Using four-engine C-130s, directorate engineers demonstrated that noise from one propeller could cancel out the noise from another propeller when properly synchronized. The decrease in sound is significant in reducing pilot and crew fatigue, in mitigating exposure to prolonged noise and elevated noise levels, and in retaining the ability to hear.

Background

The propellers of C-130 aircraft emit a low, resonating tone, precipitating the need to reduce the acoustic signature. The directorate's bioacoustics expertise was key in that effort.

The directorate conducted in-flight and ground noise measurements of the advanced synchrophaser control unit to determine if controlling the propeller phase angles of C-130 type aircraft could reduce the noise. During the flight test, aircrew noted test points where cockpit noise levels were so low, they had to remove their hearing protection to be assured that the engines were operating. In fact, the directorate identified a 22 dB reduction in cockpit noise levels during that particular phase of the testing.

The directorate demonstrated a basic synchrophaser system for twin-engine aircraft in 1992, based on a manually tuned system with no phase control. Two years later, the directorate produced the first digital synchrophaser that controlled the propeller phase by regulating the fuel flow to obtain a 10-15 dB interior noise reduction in an OV-10 twin-engine propeller aircraft.

However, the C-130 Active Synchrophaser System uses acoustic feedback from microphones specifically arranged and mounted to the fuselage or by a personal computer-based controller to find the correct phase for reducing noise levels. The C-130 Active Synchrophaser System demonstrated that significant noise-level reductions can be accomplished for turboprop aircraft without affecting the basic aircraft performance.

Additional information

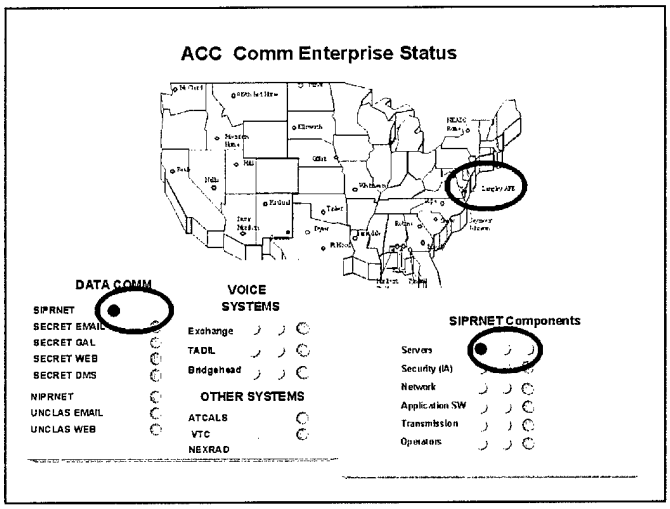
To receive more information about this or other activities in the Air Force Research Laboratory, contact TECH CONNECT, AFRL/XPTC, (800) 203-6451 and you will be directed to the appropriate laboratory expert. (03-HE-07)

Air Force Research Laboratory|AFRL

Science and Technology for Tomorrow's Air and Space Force

Success Story

AIR FORCE COMMUNICATIONS ENTERPRISE MANAGEMENT SYSTEM



The Information Directorate's Air Force Communications Enterprise Management (ACEM) system provides a tool to display high-level status of the entire communications enterprise, the overall status of a mission's communications enterprise, and the communications status for each of the mission's functional areas. The ACEM manages data networks (routers, servers, hosts) and communications systems that are not network-aware such as flight line systems, transmission systems, and switching systems (voice/ video switches, multiplexers, fiber and wireline systems, radios and radio nets, satellite communication systems).

This Web-enabled software system provides visibility into the communications enterprise for any level of interest. The ACEM alleviates the current "stove piping" of communications management and control tools by taking status information from these tools, consolidating and translating the information, and presenting overall communications status in an operational context, thus allowing personnel to know the operational impact of communications faults and attacks.

Air Force Research Laboratory
Wright-Patterson AFB OH

Accomplishment

ACEM builds comprehensive enterprise awareness by collecting information from existing tools as well as directly from information provider (IP) devices when needed and from non-IP devices. ACEM's decision support function then allows the translation of this pool of technical data into relevant, mission-oriented views that are scalable from a Major Command perspective to a functional support concern (Logistics) and even to an individual unit's area of interest.

The ACEM provides situational awareness of the entire communications enterprise and translates technical status information into a view of each organization's (Operations, Headquarters, Medical, Support) communications health. This allows prioritized restoration of service and the best possible quality of service.

An ACEM server can obtain specific technical status information from each communications management tool and combine that with other ACEM status information to determine and present communications enterprise status in an operational, mission-oriented context. The ACEM objective is to allow anyone from the commander to the shift worker to access the communications status and the operational impact of faults and attacks.

Background

The ACEM completed an operational demonstration at the Air Combat Command Network Operations Security Center, where it received and translated status information from the unclassified but sensitive Internet Protocol Router Network, the secret Internet Protocol Router Network, and non-IP devices. Currently, the directorate is integrating ACEM with the Multi-Domain Network Manager (MDNM), the Master Caution Panel (MCP), and the AF Enterprise Defense (AFED) to form the Command and Control Enterprise Management System (C2EMS).

The MDNM builds an integrated network management capability across multiple security domains (unclassified, secret, top secret, sensitive compartmented information, coalition). MCP provides situational awareness of command centers and application programs. The AFED provides intrusion detection and network defense. The C2EMS will provide situational awareness of the status of the entire C2 enterprise.

Additional information

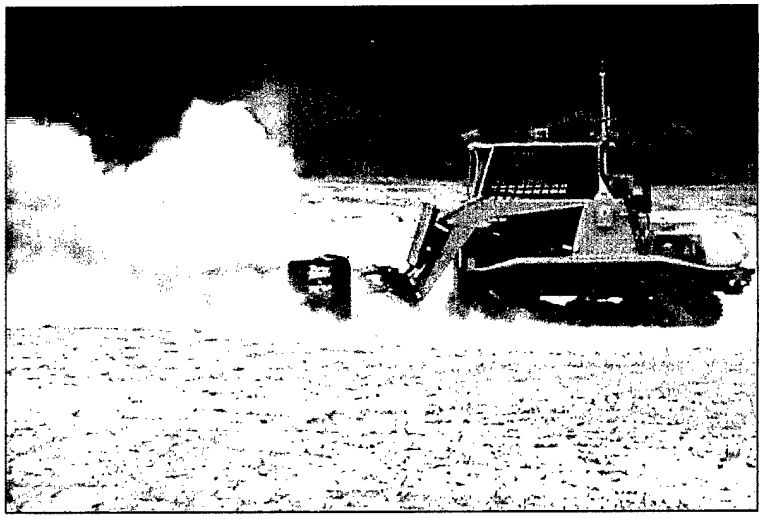
To receive more information about this or other activities in the Air Force Research Laboratory, contact TECH CONNECT, AFRL/XPTC, (800) 203-6451 and you will be directed to the appropriate laboratory expert. (03-IF-03)

Air Force Research Laboratory|AFRL

Science and Technology for Tomorrow's Air and Space Force

Success Story

ALL-PURPOSE REMOTE TRANSPORT SYSTEM SUPPORTS FORCE PROTECTION AND ACTIVE RANGE CLEARANCE ACTIVITIES



The All-purpose Remote Transport System (ARTS) provides the warfighter with a robust suite of tools to accomplish force protection and active range clearance activities. It allows the warfighter to stay out of harm's way since no human is onboard. All of the ARTS components are commercial off-the-shelf items designed to withstand intense conditions.

The vehicle's components allow technicians to make quick and inexpensive repairs when damage does occur and move the vehicle control computer and software package from one vehicle platform to the next, reducing duplication of effort while maximizing commonality across all platforms. The removal of the operator from the hazard area also reduces the requirement for expensive and bulky armor plating.

Air Force Research Laboratory
Wright-Patterson AFB OH

Accomplishment

Engineers at the Materials and Manufacturing Directorate developed a low-cost, survivable platform capable of remote operations in a variety of mission profiles. ARTS, developed in cooperation with Headquarters Air Combat Command and the 99th Civil Engineering Group, Nevada Test Range, already established its value during range clearance operations and demonstrated great potential for success in force protection, fire fighting, natural disaster cleanup, inclimate weather operations, range remediation, and active range clearance.

Background

Following the tragic incident at Khobar Towers in June 1996, Air Force officials identified a need for the ability to safely remove or disable terrorist bombs. Systems used at this time were too small to remove these improvised explosive devices or disable weapons of mass destruction in such incidents, so the directorate's Airbase Technologies Division began working on alternatives.

The division's Robotics Research Group, part of the Office of the Secretary of Defense Joint Robotics program, coordinates the Air Force effort to develop robotic technologies and systems that provide land forces with highly mobile, multi-mission, unmanned ground vehicles to achieve leap-ahead capabilities across a wide spectrum of mission challenges. With the support of a contract team, the directorate immediately sought to develop technology to respond to these critical real-world situations.

The ARTS is a modified version of a standard light construction tractor, the Posi-Track™ MD70, manufactured and distributed by All Season Vehicle, Inc., Grand Rapids, Minnesota. The platform has a four-cylinder, liquid-cooled diesel engine that delivers power to the 18-inch wide, Kevlar-reinforced rubber tracks through a dual hydrostatic transmission.

The tracks have over 3,000 square inches of contact area, resulting in ground contact pressure of approximately 2 pounds-per-square-inch. This vehicle profile allows for a low center of gravity and light footprint, which makes the rugged and reliable vehicle the perfect candidate for range operations by minimizing forces that could detonate sensitive munitions.

The Air Force has seen significant success for ARTS, as explosive ordnance disposal (EOD) specialists have used it for unexploded ordnance clearance and remediation. The Air Force currently operates several active bombing ranges where pilots train by dropping advanced and lethal anti-armor/anti-personnel weapons. EOD specialists must periodically clear debris such as bomb fragments, unexploded munitions, and other hazardous items.

Additional information

To receive more information about this or other activities in the Air Force Research Laboratory, contact TECH CONNECT, AFRL/XPTC, (800) 203-6451 and you will be directed to the appropriate laboratory expert. (03-ML-07)

Air Force Research Laboratory|AFRL

Science and Technology for Tomorrow's Air and Space Force

Success Story

CANADA TO IMPLEMENT +100 FUEL ADDITIVE

The +100 additive, developed by the Propulsion Directorate's Fuels Branch, minimizes maintenance associated with fuel degradation in aircraft engines and fuel systems. The +100 additive significantly reduces fuel-related maintenance costs for a wide range of military and commercial systems.

Air Force Research Laboratory
Wright-Patterson AFB OH

Accomplishment

Canadian Forces recently announced their intentions to convert their ground-based air operations from North Atlantic Treaty Organization (NATO) F-40 (military JP-4) fuel to NATO F-37, also known as JP-8+100 fuel. This shift will make Canada the third NATO member to adopt the +100 thermal stability fuel additive following the lead of the United States and Denmark.

Background

Canada plans to transition from F-40 to F-37 in 2003. At the end of the transition period, current F-40 suppliers in Canada, which include Shell and Petro-Canada, will stop producing F-40/Jet B-type fuel.

Canada is currently putting the infrastructure in place to supply fuel with the +100 additive to aircraft. Their planning provides for various means of injecting the additive into the fuel including injection at the loading rack, on refueling vehicles, or with a portable unit.

However, Canada will not put +100 additive into storage tanks since aircraft not converting to the +100 additive will not be able to use the fuel. Canadian Forces will retain the flexibility to use both fuels. They will provide F-34 (JP-8) without the +100 additive to non-program or transient aircraft and will retain the F-44 (JP-5) fuel for shipboard operations.

Propulsion
Support to the Warfighter

Additional information

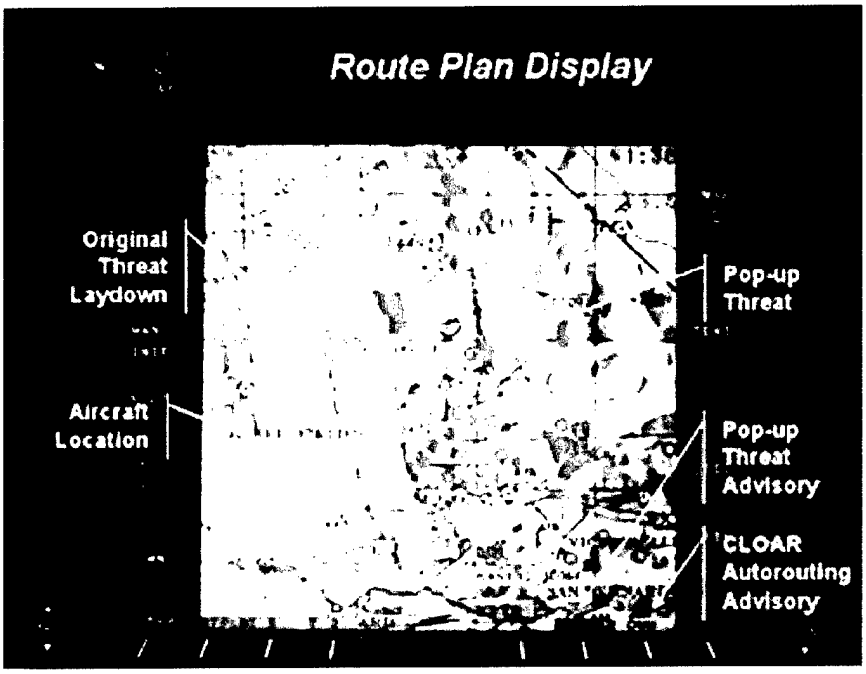
To receive more information about this or other activities in the Air Force Research Laboratory, contact TECH CONNECT, AFRL/XPTC, (800) 203-6451 and you will be directed to the appropriate laboratory expert. (03-PR-01)

Air Force Research Laboratory|AFRL

Science and Technology for Tomorrow's Air and Space Force

Success Story

FIGHTER AIRCRAFT EVALUATE REAL-TIME INFORMATION CAPABILITY



The Integrated Real-time information into the cockpit (RTIC)/Real-time information out of the cockpit (RTOC) for Combat Aircraft (IRRCA) program made F-117 history when the aircraft sent its first-ever attack sequence images via satellite data link during IRRCA Phase II flight testing. Personnel from the Sensors Directorate, Lockheed Martin Aeronautical Systems, and the F-117 Combined Test Force in Palmdale, California, conducted the flight testing.

The ability to send images of an attack sequence to a command and control element within minutes of the attack allows commanders to assess the effectiveness of an attack and rapidly redirect an attack against the target, if necessary. This capability is critical for time-critical targeting operations.

Air Force Research Laboratory
Wright-Patterson AFB OH

Accomplishment

The IRRCA program developed an onboard mission manager (OMM) that facilitates the transfer of RTIC and RTOC. The OMM also contained a modified version of the common low-observable auto-router (CLOAR) that allows a dynamic, signature-managed replan of the F-117's flight path in response to target retasking messages and pop-up threats. The IRRCA avionics configuration also supports sending selected images with mission reports via satellite data links that provide beyond line-of-sight communication with the aircraft.

Background

The directorate initiated the IRRCA program in 1998 and restructured it in January 2000, adding extended hot mock-up (HMU) testing. HMU testing, completed in June 2001, allowed for additional configuration testing and consisted of mission updates, text, and image messages sent from the Raytheon, Ft. Wayne, Indiana location to the F-117A HMU facility in Palmdale, California, over ultra high frequency demand assigned multiple access satellite communications (UHF DAMA SATCOM).

The multi-mission advanced tactical terminal received threat updates transmitted on the national threat broadcasting system and passed the threat updates to the OMM. The CLOAR replanned the route, which was dependent upon the mission updates and threat information passed to the OMM. During the attack phase of the mission, the HMU captured a series of images from the infrared targeting system and sent them via UHF DAMA SATCOM to a simulated air operations center.

Additional information

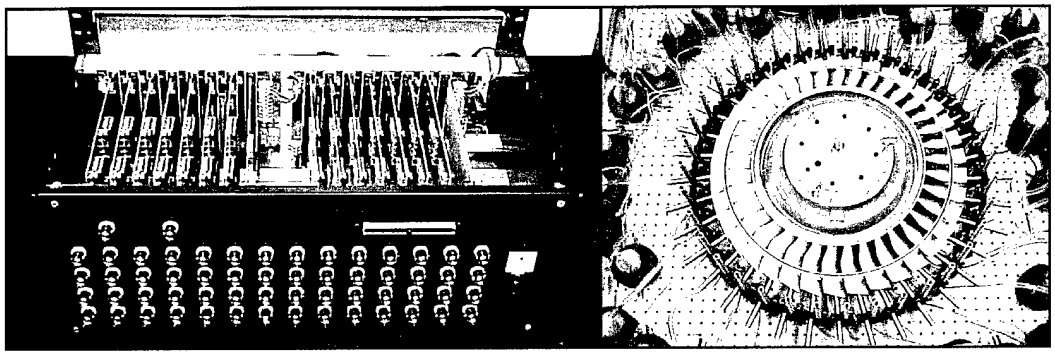
To receive more information about this or other activities in the Air Force Research Laboratory, contact TECH CONNECT, AFRL/XPTC, (800) 203-6451 and you will be directed to the appropriate laboratory expert. (03-SN-08)

Air Force Research Laboratory|AFRL

Science and Technology for Tomorrow's Air and Space Force

Success Story

TEST MODIFICATION PREVENTS IHPTET DELAYS



A team of engineers and scientists in the Propulsion Directorate's Turbine Engine Fatigue Facility (TEFF) kept a national collaborative program on track by expanding and modifying their test hardware to measure a one-of-a-kind engine component, all without significant cost. The TEFF Team completed the entire test program in the 2 weeks between engine tear down and the required delivery to the machine shop for modification.

The team's quick response in making the necessary modifications to the test and data acquisition systems provided high-fidelity data to the program without any adverse effects on the planned schedule. The TEFF Team maintained the test schedule for the XTC 76/3B, which is critical to reaching Integrated High Performance Turbine Engine Technology (IHPTET) Phase 3 goals as demonstrated through the XTE 77/1.

Air Force Research Laboratory
Wright-Patterson AFB OH

Accomplishment

The TEFF Team of engineers and scientists developed and implemented a redesign to their traveling wave excitation system in order to support the third phase of the IHPTET program. The team used the excitation system to measure high response resonant modes with laser scanning vibrometry and test the unique core-driven fan stage (CDFS) of the XTC 76/3 demonstration engine.

In less than 6 weeks, directorate engineers redesigned and expanded the excitation system electronic circuitry from 18 to 37 necessary channels for the experiments. They also expanded the laser scanning vibrometry capability—in both number of excitation channels and laser scan field-of-view—to enable coverage of the 40-inch bladed disk (blisk).

Background

The CDFS is a unique integrally machined blisk stage incorporating two distinct stacked blade rows in a single stage. This design is unique to General Electric Aircraft Engines and Allison Advanced Development Company and is one of only two components of this type ever produced.

Due to its geometric features and unique design, conventional finite element analysis and laser vibrometry produced inconsistent results. Since large amplitude vibrations were experienced in the 1st flex (trailing edge dominated) mode at partial power and the 2nd stripe mode near maximum power during engine testing, directorate engineers needed insight into the structural dynamics characteristics of the entire blisk to ensure proper redesign and modification by the manufacturer. Directorate engineers required complete testing to avoid large amplitude resonances when the engine returns to test as the XTC 76/3B in early fiscal year 2003.

Using acoustic excitation, directorate engineers performed chirp tests covering a frequency range of 0 to 9000 Hz on both the fan and the core airfoils. The engineers used the scanning vibrometer to obtain the dynamic response characteristics of all airfoils, on both inner and outer panels, for all resonant modes that exist in the operating range of the engine.

Directorate engineers also measured mistuning patterns, stress localization, and phase relationships between inner and outer panels. The data obtained in this test program validated the intended modifications to the blisk and permitted the return to the demonstrator engine safely and expeditiously.

Propulsion
Emerging Technologies

Additional information

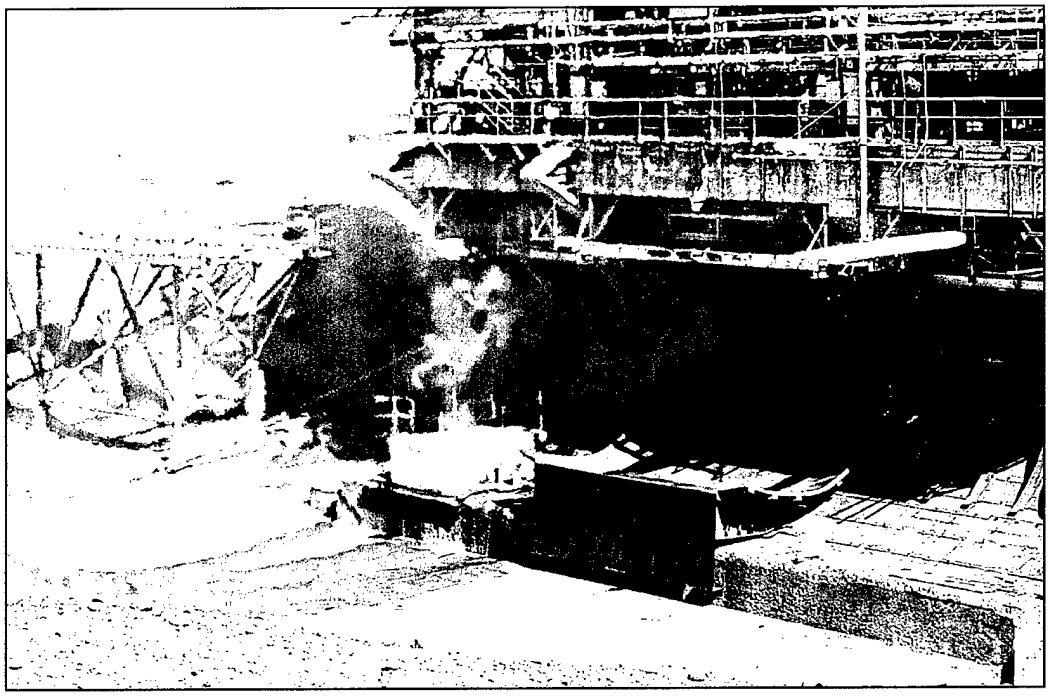
To receive more information about this or other activities in the Air Force Research Laboratory, contact TECH CONNECT, AFRL/XPTC, (800) 203-6451 and you will be directed to the appropriate laboratory expert. (03-PR-03)

Air Force Research Laboratory|AFRL

Science and Technology for Tomorrow's Air and Space Force

Success Story

INTEGRATED POWERHEAD DEMONSTRATION PROJECT ENTERS FAST-PACED TEST PHASE



Testing is under way of critical components for integration into the world's first full-flow-cycle hydrogen/oxygen boost engine. A recent test of the Propulsion Directorate's Integrated Powerhead Demonstration (IPD) project in California established a technical first for the United States (US) and marks the first advancements in boost engine technology since the initial development of the Space Shuttle Main Engine (SSME) in the 1970s.

Air Force Research Laboratory
Wright-Patterson AFB OH

Accomplishment

Testing of the Department of Defense's (DoD's) IPD project is under way at the Aerojet E-Complex test facilities in Sacramento. Directorate engineers successfully tested the IPD fuel preburner to 50% power, satisfying all pretest predictions and meeting all test objectives. The fuel preburner will eventually deliver hot hydrogen drive gas to power an advanced hydrogen turbo pump in the engine system.

This successful test kicks off a new stage in the IPD program where directorate engineers will test combustion and turbo machinery components at both Aerojet and the National Aeronautics and Space Administration's (NASA's) Stennis Space Center in Mississippi. Following this test phase, directorate engineers will integrate all components into the world's first full-flow-cycle hydrogen/oxygen boost engine.

Background

The IPD program supports the DoD Integrated High Payoff Rocket Propulsion Technology (IHPRPT) program. The goal of this program is to double the capability of boost engines for access to space. The IPD program is also a very successful partnership between AFRL and NASA's Marshall Space Flight Center in Huntsville, Alabama, which provides additional technical expertise and program support.

IPD's full-flow staged combustion engine is a technical first for the US. The program brings together combustion device components from Aerojet, and turbo machinery and system integration expertise from Boeing-Rocketdyne of Canoga Park, California. This combination will extend the life cycle of boost engines and reduce the amount of maintenance between missions. IPD is also the first cryogenic boost engine technology program since the development of the SSME in the 1970s.

The IHPRPT program is a DoD/NASA/industry-coordinated effort to develop revolutionary and innovative technologies by the year 2010. This effort will double rocket propulsion capabilities over early 1990s state-of-the-art technology.

Propulsion
Emerging Technologies

Additional information

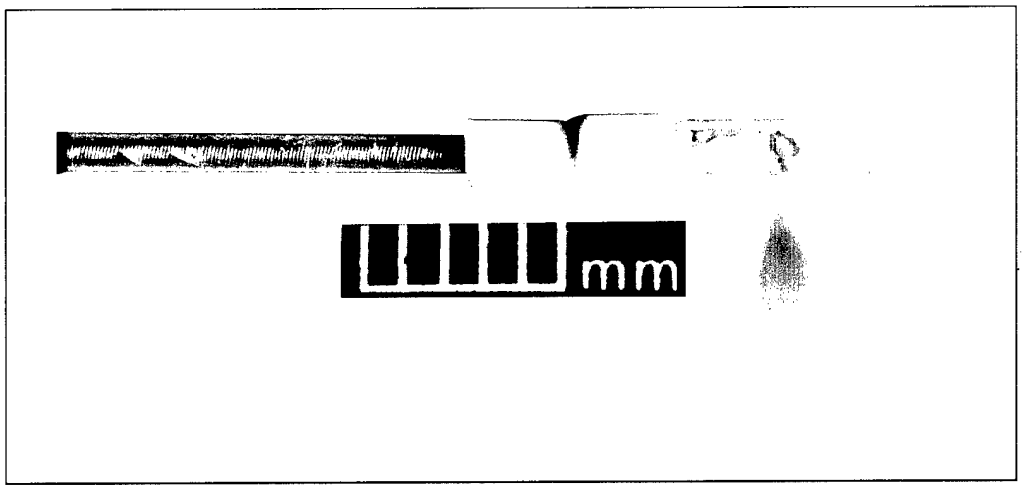
To receive more information about this or other activities in the Air Force Research Laboratory, contact TECH CONNECT, AFRL/XPTC, (800) 203-6451 and you will be directed to the appropriate laboratory expert. (03-PR-04)

Air Force Research Laboratory|AFRL

Science and Technology for Tomorrow's Air and Space Force

Success Story

BREAKTHROUGH OPTICAL TECHNOLOGY— OPTICAL COHERENCE TOMOGRAPHY



Optical Coherence Tomography (OCT) can provide high-resolution, cross-sectional imaging similar to that of ultrasound, but it uses light instead of sound. OCT, an emerging technology based on fiber optics, often uses a compact diode light source similar to those used in compact disc players.

Air Force Research Laboratory
Wright-Patterson AFB OH

Accomplishment

An Air Force Office of Scientific Research (AFOSR)-sponsored scientist, Dr. James Fujimoto, is the inventor and leading researcher of OCT, a new optical imaging tool for creating images used in medical diagnostics, materials science, and microscopy. Dr. Fujimoto, sponsored by AFOSR's Physics and Electronics Directorate, is a professor in the department of Engineering and Computer Science at the Massachusetts Institute of Technology in Cambridge, Massachusetts.

Background

OCT technology is robust, portable, low cost, and readily interfaced with optical fiber techniques to catheters, endoscopes, laparoscopes, and surgical probes. These attributes make it very attractive for medical and surgical diagnostics.

Ophthalmology, the study of the eye, is an area of medical research to benefit tremendously from this new technology, and the first area to have commercial instrumentation introduced. Researchers performed studies investigating the feasibility of using OCT for the diagnosis and monitoring of retinal diseases such as glaucoma, macular edema, macular holes, central serous chorioretinopathy, age-related macular degeneration, epiretinal membranes, optic disc pits, and choroidal tumors.

Other AFOSR-funded researchers developed valuable extensions and applications of OCT. Dr. Zhongping Chen, of the University of California, Irvine, developed Doppler OCT, which observes moving surfaces and is particularly valuable for studying blood vessel function and fluid flow, generally, in small structures.

Dr. Johannes de Boer, of the Massachusetts General Hospital (MGH), developed polarization-sensitive OCT and applied it to diagnosing burns. Drs. Brett Bouma and Guillermo Tierney at MGH, both former members of Dr. Fujimoto's group, developed very portable, high-performance OCT systems for clinical diagnostic studies. The US Army Institute for Surgical Research in San Antonio, Texas, is currently collaborating with several AFOSR-funded scientists to apply OCT to military medical needs.

Office of Scientific Research
Emerging Technologies

Additional information

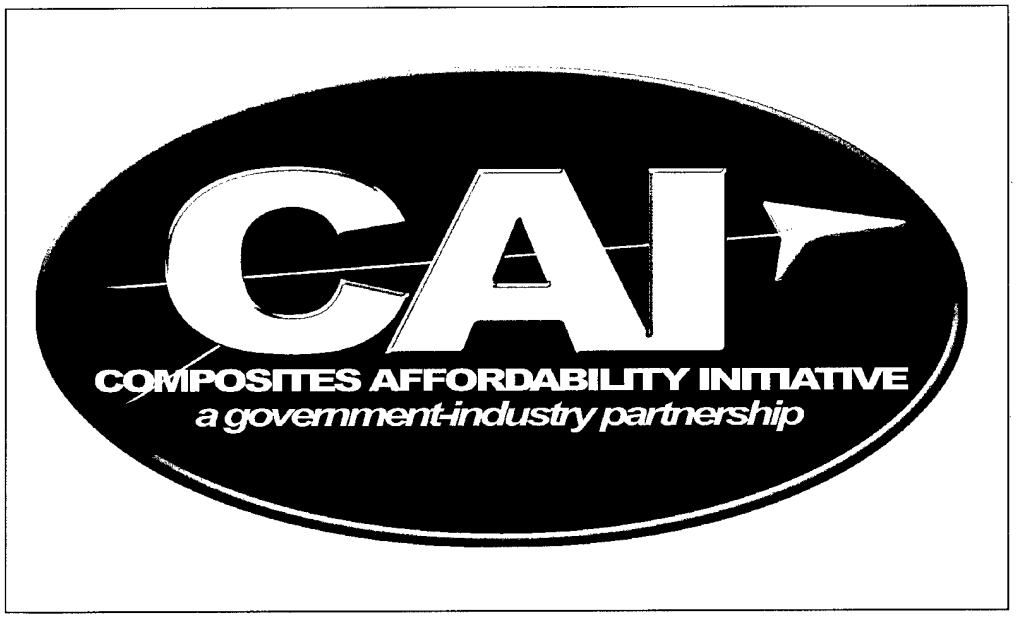
To receive more information about this or other activities in the Air Force Research Laboratory, contact TECH CONNECT, AFRL/XPTC, (800) 203-6451 and you will be directed to the appropriate laboratory expert. (02-OSR-10)

Air Force Research Laboratory|AFRL

Science and Technology for Tomorrow's Air and Space Force

Success Story

CORTM PROCESS REDUCES FABRICATION AND ASSEMBLY COSTS FOR COMPOSITE STRUCTURES



The cocuring of the substructure and skin by means of the Cocuring of an uncured skin to a Resin Transfer Molded (CoRTM) process is an effective way to reduce the cost of fabrication and assembly. The CoRTM process reduces part count along with the associated fasteners. The dimensional precision and repeatability of the resin transfer molding process also enables the use of Z-reinforcement technologies such as Z-pins and three-dimensional preforms, increasing the potential applications by enhancing structural performance.

Air Force Research Laboratory
Wright-Patterson AFB OH

Accomplishment

The Composites Affordability Initiative (CAI) Team, consisting of the Materials and Manufacturing Directorate, the Air Vehicles Directorate, the Navy's Office of Naval Research, Boeing, Lockheed Martin, and Northrop Grumman, demonstrated a process that can dramatically reduce the costs of composite fabrication and assembly. The CoRTM process, developed by Northrop Grumman, produces large, integrated, weight-efficient, precise, and repeatable structures.

The CAI Team used a vertical stabilizer from the Joint Strike Fighter (JSF) to demonstrate the technology. Using CoRTM to manufacture that part could lead to nearly $14,000 in savings derived through a 52% reduction in part count, a 38% reduction in tool count, a 7% reduction in weight, and a 17% overall cost reduction when compared to the typical JSF construction process and the associated fit-up, liquid shimming, and surface mold line treatments for air vehicles.

Background

Traditional aircraft structures consist of multiple piece assemblies that manufacturers pre-fit together, filling gaps between mating surfaces with shim materials to create a snug fit, and then mechanically fastening in place. This results in very lengthy manufacturing flow times and high acquisition costs.

Through CAI, the CoRTM process is a viable and promising alternative for affordable composite structures. CoRTM combines two cost-effective processes: fiber placement (the automated placement of bands of high-strength fibers combined with resin onto a tool) for skin structures, currently used on JSF, F-18, V-22, F-22, etc.; and resin transfer molding (the injection of high-strength resin into a mold containing high-strength fibers formed to a specified shape) for substructures currently used on the F-22 Raptor and other aircraft.

Instead of fastening the skin to the substructure, the CoRTM process designs and fabricates the skin and the substructure as a single component, eliminating the need to fasten them together. After the fiber placement process lays up the uncured skin, the manufacturer builds up the substructure by placing and tooling dry fiber preforms on top of the uncured skins. The manufacturer then injects the preforms with resin and cures the whole assembly to form the structure.

For more information on CoRTM or the CAI, call the Technology Information Center at (937) 255-4689. Refer to item number 02-068.

Materials and Manufacturing
Emerging Technologies

Additional information

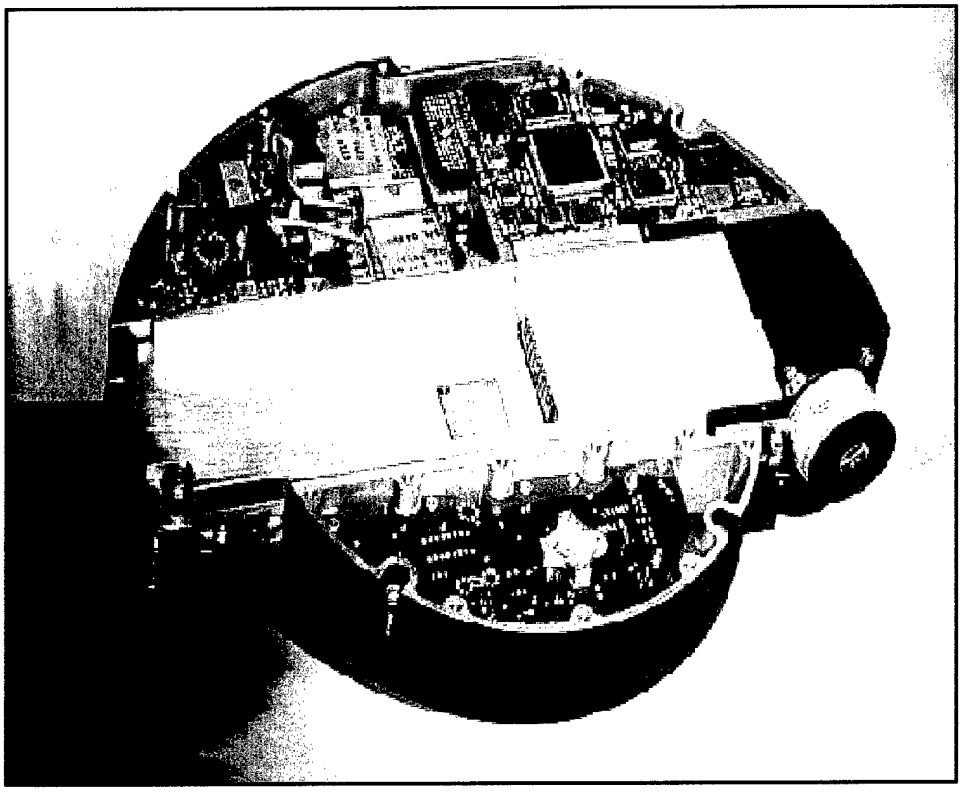
To receive more information about this or other activities in the Air Force Research Laboratory, contact TECH CONNECT, AFRL/XPTC, (800) 203-6451 and you will be directed to the appropriate laboratory expert. (03-ML-02)

Air Force Research Laboratory|AFRL

Science and Technology for Tomorrow's Air and Space Force

Success Story

VIPER™ MID-IR LASER AIRCRAFT DEFENSE SYSTEM RETURNS HUGE SAVINGS ON INVESTMENT



Northrop Grumman, under contract with the Materials and Manufacturing Directorate's Manufacturing Technology (ManTech) Division successfully developed significant cost-saving procedures in the manufacture and assembly of the Viper Mid-Infrared (IR) Laser. The directorate estimates a net savings of $4.2 million for the first 250 units, as well as a dramatic increase in yield and reliability improvements in life-cycle costs and increased system availability, without degrading the performance of the Viper.

Air Force Research Laboratory
Wright-Patterson AFB OH

Accomplishment

The Viper Mid-IR Laser is one of the primary components in the Large Aircraft IR Countermeasures (LAIRCM) system, designed to protect C-17s, C-130s, and other large aircraft from IR-guided surface-to-air missiles. The LAIRCM will autonomously detect and signal the flight crew when the aircraft is threatened. It will track and then jam the missile's guidance system, saving both aircrew and aircraft.

ManTech and Northrop Grumman representatives reduced costs for the Viper by addressing manufacturability, maintainability, reliability, supportability, and availability issues. These cost reductions would, in turn, save money on the LAIRCM program.

Background

One example of the steps taken by ManTech and Northrop Grumman representatives to accomplish cost reductions was the insertion of Lean Practices and Principles to increase yield, reduce rework, and touch labor costs. In general, they made design and manufacturing process changes that reduced deficiencies and the number of assembly and adjustment steps for the electronic and optical components.

Another example was the high-value electronics, optics, and other materials that were only available from a single supplier. ManTech obtained multiple supplier sources, creating more competition and driving the cost down by substituting standardized components for specialized ones.

Additional information

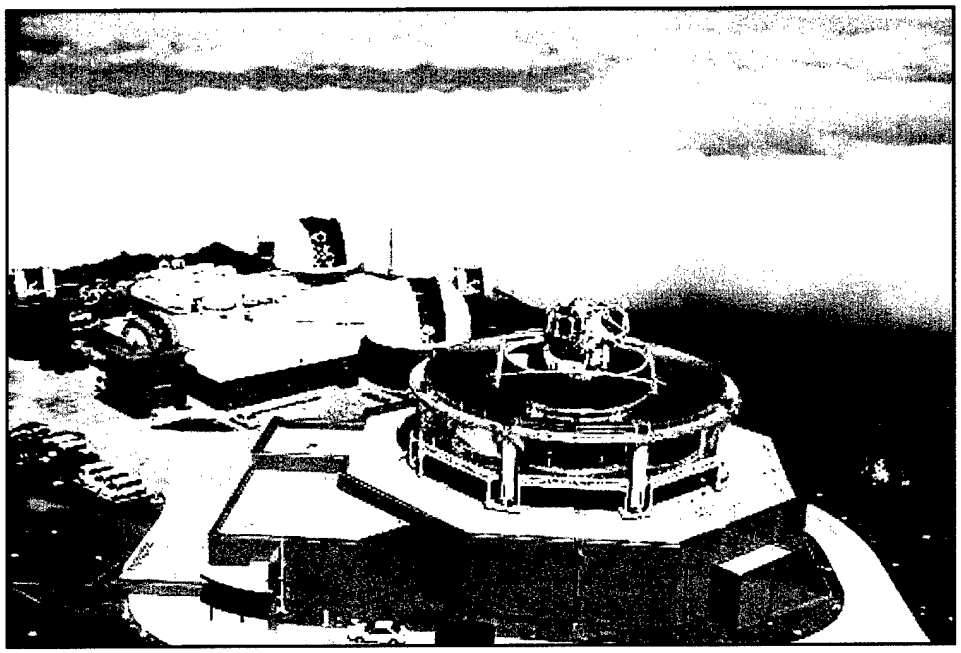
To receive more information about this or other activities in the Air Force Research Laboratory, contact TECH CONNECT, AFRL/XPTC, (800) 203-6451 and you will be directed to the appropriate laboratory expert. (03-ML-10)

Air Force Research Laboratory|AFRL

Science and Technology for Tomorrow's Air and Space Force

Success Story

DIRECTED ENERGY DIRECTORATE DEMONSTRATES HIGH-ACCURACY ORBIT UPDATES FOR LEO SATELLITES



Directed Energy Directorate scientists and engineers used the 3.6- and 1.6-meter telescopes at the Air Force Maui Optical and Supercomputing (AMOS) site to track orbiting satellites and provide high-accuracy trajectory updates. This capability is a combination of state-of-the-art telescope pointing accuracy as well as world-class astrodynamics expertise unique to the AMOS facility.

Air Force Research Laboratory
Wright-Patterson AFB OH

Accomplishment

Directorate scientists made high-accuracy observations of low earth orbiting satellites at the one- to two-arcsecond levels with the 3.6- and 1.6-meter telescopes. The resulting calculation of satellite trajectories showed a significant decrease in orbit error from several hundred meters to tens of meters. This high-accuracy orbit update capability represents an unprecedented achievement in orbital prediction.

Directorate scientists then fed this data into a Kalman filter to update the calculated satellite trajectories showing a decrease in orbit error from the several- hundred-meter levels to the tens-of-meter levels. While normal satellite catalogue maintenance focuses mainly on achieving required accuracy for all satellites, this approach provides high accuracy for any specific satellite.

Background

Directorate scientists and engineers rebuilt the research and development capability of the AMOS site since taking oversight of the facilities from the Air Force Space Command. The directorate's Metrics Research and Development program made great strides in the last year due to continued sensor development, high-accuracy data collection, and the arrival of data exploitation expertise. This combination makes AMOS a national asset to the Department of Defense for space surveillance, and orbit determination and prediction research.

The directorate's AMOS Branch recently worked with the Missile Defense Agency Theater High-Altitude Area Defense program as part of a risk-reduction effort for the augmented recursive dual channel estimator for registration (ARCHER) algorithm demonstration. For missile defense, it is critical that sensors sharing data provide the data in an unambiguous manner; otherwise, inaccurate data will result in miscorrelations between actual radar tracks and externally supplied information.

ARCHER is an innovative approach for radar data registration in support of missile defense sensor networks. Directorate engineers used the high-accuracy orbit update capability at AMOS to develop "truth" orbits for this risk-reduction effort. In addition, the high-accuracy orbit update capability has applications to space control, space situational awareness, active tracking, and for Air Force missions requiring precise knowledge of satellite trajectories.

Directed Energy
Emerging Technologies

Additional information

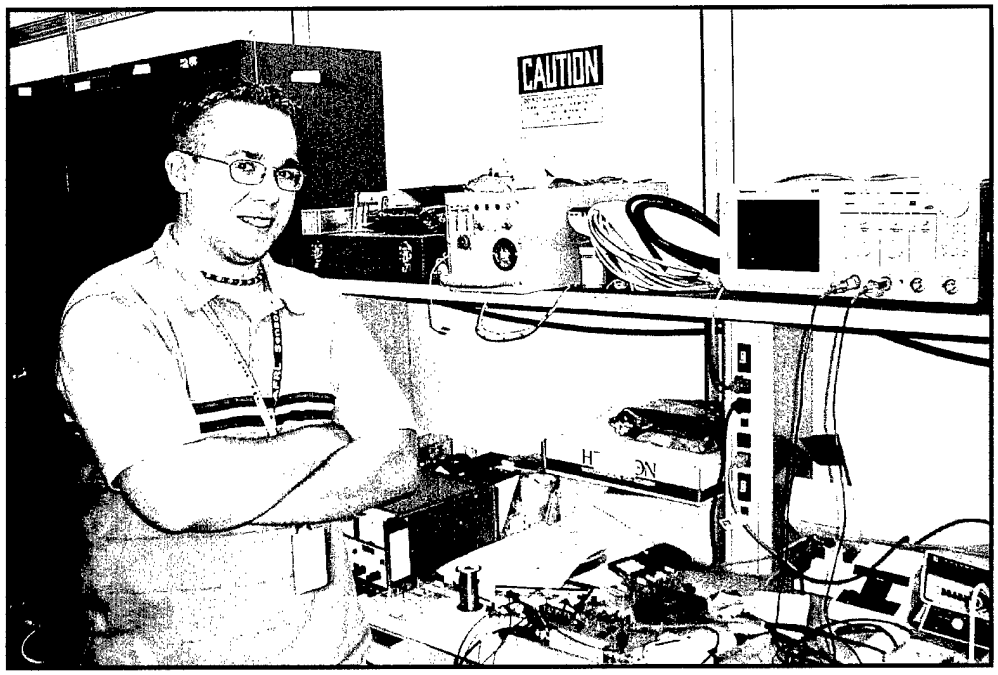
To receive more information about this or other activities in the Air Force Research Laboratory, contact TECH CONNECT, AFRL/XPTC, (800) 203-6451 and you will be directed to the appropriate laboratory expert. (03-DE-01)

Air Force Research Laboratory|AFRL

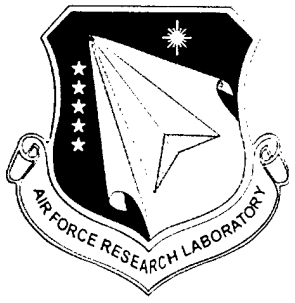
Science and Technology for Tomorrow's Air and Space Force

Success Story

PACTS PROVIDES SENSORS DIRECTORATE A MORE RELIABLE VFT CAPABILITY



The Sensors Directorate developed a controller called Programmable Attenuator Control and Test System (PACTS) that uses basic logic and inexpensive integrated circuits (under $5) to make the directorate's virtual flight test (VFT) capability more reliable. The PACTS provides output signals to an attenuator in the same mode and timing that the radio frequency (RF) controller uses to control the attenuators in the VFT simulation.



Air Force Research Laboratory
Wright-Patterson AFB OH

Accomplishment

A bank of programmable attenuators caused significant RF glitches in the directorate's Advanced Concepts Exploration Global Positioning System's (GPS) VFT simulation. Attenuators use RF signals generated from the GPS and threat simulators to reduce the power to simulate real-world terrain effects and propagation losses observed at the platform.

Mr. Ron Franks, a 2002 Cedarville University co-op student, analyzed these wavelengths in the time domain (milliseconds) versus the traditional frequency domain (sine wave). Running direct current voltage through the attenuator demonstrated a notable pause as the internal relay switched, causing the attenuator to spike. To address this, Mr. Franks constructed PACTS and created the solution within 3 days.

Background

For over 4 years, significant RF glitches in the VFT simulation led to occasional spikes, which caused anti-jamming systems undergoing testing to see this phenomenon and, at times, invalidate the testing. Directorate engineers analyzed the data extensively in the frequency, but not in the time domain.

Directorate engineers investigated several possible hardware fixes over time, but found them far too costly and time-consuming as viable options. The PACTS provided output signals to an attenuator in the same mode and timing as used by the RF controller, thus solving the problem.

Sensors
Emerging Technologies

Additional information

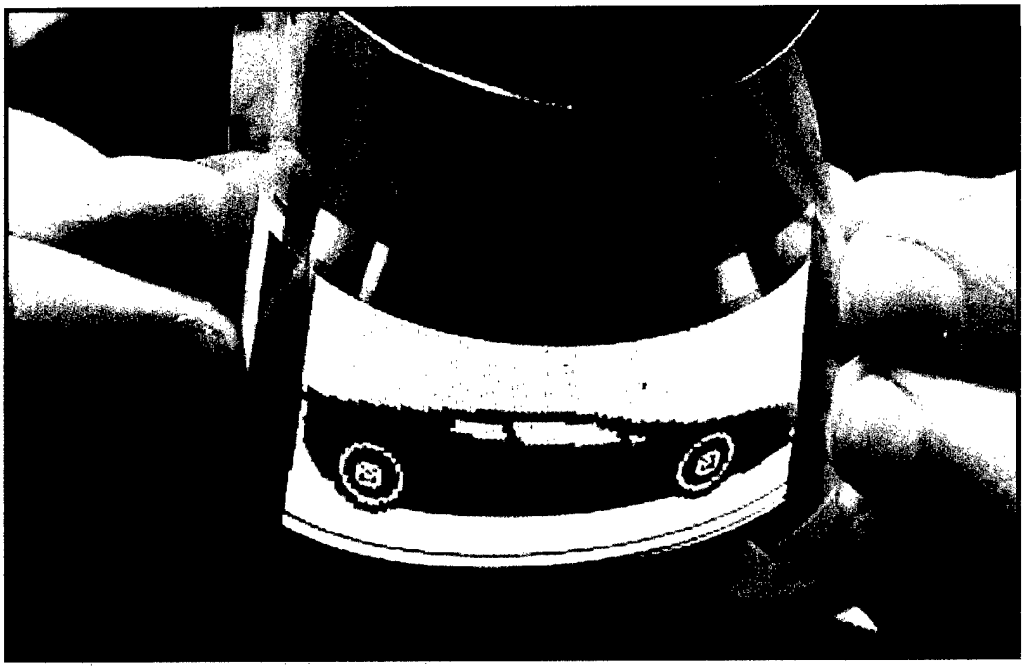
To receive more information about this or other activities in the Air Force Research Laboratory, contact TECH CONNECT, AFRL/XPTC, (800) 203-6451 and you will be directed to the appropriate laboratory expert. (03-SN-07)

Air Force Research Laboratory|AFRL

Science and Technology for Tomorrow's Air and Space Force

Success Story

HUMAN EFFECTIVENESS DIRECTORATE TRANSFERS REVOLUTIONARY DISPLAY TECHNOLOGY TO INDUSTRY



The Human Effectiveness Directorate created key technology for a breakthrough electronic display and transferred it to an industrial consortium led by the Universal Display Corporation (UDC) in Ewing, New Jersey.

Air Force Research Laboratory
Wright-Patterson AFB OH

Accomplishment

Organic light-emitting devices (OLEDs) are a new class of displays with properties that make them highly attractive for a broad array of military and commercial uses. OLEDs are thin, flat, and lightweight; emit bright light with little power; are readable at very wide viewing angles; and are flexible and transparent.

The directorate-managed, Defense Advanced Research Projects Agency (DARPA)-funded High-Definition System (HDS) program helped create materials, devices, and fabrication processes essential to OLED production. UDC will produce prototypes for evaluation in military avionics by L3 Communications in Marietta, Georgia, and will establish economic viability via partnerships with several companies pursuing consumer electronic applications.

Background

Princeton University, the University of Southern California, Hughes Research Laboratory, and UDC performed the project, which was possible through a grant as part of the HDS program. DARPA provided $5.5M to fund the HDS program, which focused on creating a variety of affordable display technologies capable of displaying digital high-definition television.

Human Effectiveness
Technology Transfer

Additional information

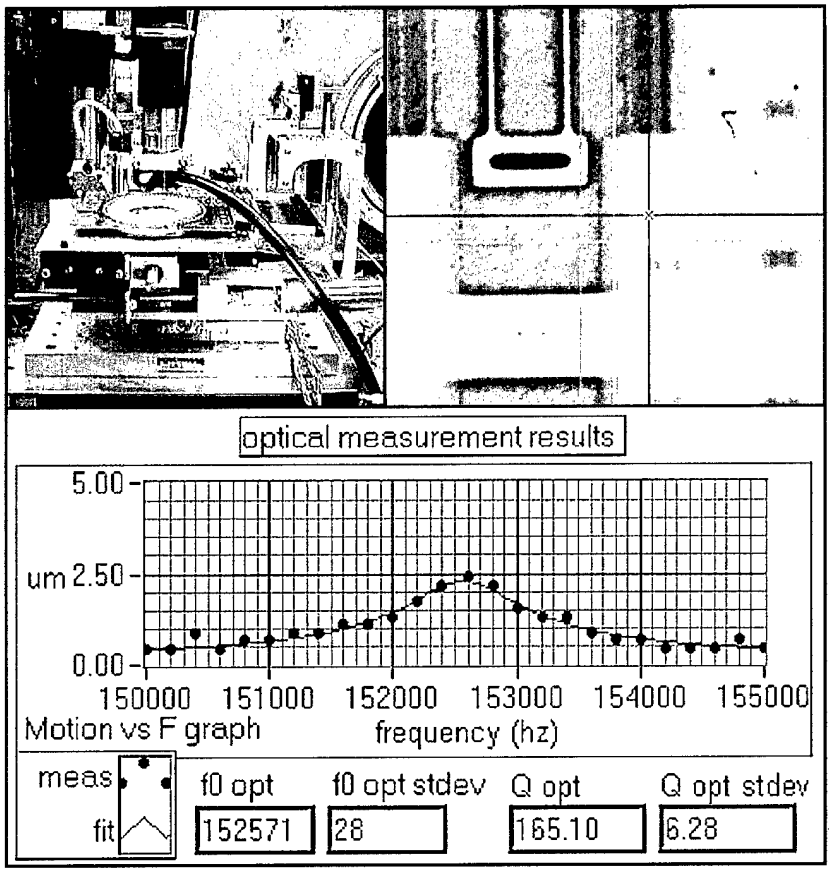
To receive more information about this or other activities in the Air Force Research Laboratory, contact TECH CONNECT, AFRL/XPTC, (800) 203-6451 and you will be directed to the appropriate laboratory expert. (03-HE-05)

Air Force Research Laboratory|AFRL

Science and Technology for Tomorrow's Air and Space Force

Success Story

MEMS TECHNOLOGY DESIGN EVALUATION TEST BED



An Information Directorate-developed microelectromechanical systems (MEMS) test bed technology is enabling the development of a new generation of low power, rugged smart sensors and actuators that integrate mechanical, optical, fluidic, and electronic devices on a single chip. This unique new MEMS test bed is capable of rapid, accurate characterization of MEMS prototypes and products.

Air Force Research Laboratory
Wright-Patterson AFB OH

Accomplishment

Interscience, Inc. of Troy, New York, developed the MEMSPEC™ product by incorporating a directorate-developed software that contains a patented Blur Synthesis Matching image-processing technique. This instrument can measure both horizontal and vertical displacements with nanometer resolutions in a vacuum or controlled atmospheric environment. The directorate's method enables characterization of MEMS motions at significantly higher frequencies than prior art.

Background

This MEMS technology evolved from MEMS program work co-sponsored by the directorate and the Defense Advanced Research Projects Agency/ Microsystems Technology Office. The directorate was the agent for this program and contributed in-house work focused on the design, evaluation, and improvement of MEMS resonators.

Interscience developed the MEMSPEC instrument as the first commercial MEMS tester. Previously, this instrument was capable of only coarse (1 um), slow (150 kHz) horizontal measurement capability, and prior methods used in other instruments were constrained to measuring the motions of MEMS below about 200 kHz.

Use of the new AFRL-developed measurement method removes that frequency limit. Directorate researchers expect the availability of the new instrument to speed the refinement of future generations of high-frequency MEMS systems.

Information
Technology Transfer

Additional information

To receive more information about this or other activities in the Air Force Research Laboratory, contact TECH CONNECT, AFRL/XPTC, (800) 203-6451 and you will be directed to the appropriate laboratory expert. (03-IF-02)

Air Force Research Laboratory|AFRL

Science and Technology for Tomorrow's Air and Space Force

Success Story

LIFE-SAVING VEIN VIEWING TECHNOLOGY DELIVERED TO MEDICAL COMMUNITY

Manufacturing the vein viewer device will provide both the Air Force and the medical community with a solution to the need for a reliable, accurate, and inexpensive point-of-care device for viewing a patient's veins rapidly and accurately, in conditions where the lighting is less than optimal. On the battlefield, in hospitals, and at the scene of accidents, prompt intravenous (IV) administration has the potential of saving countless lives.

During the course of this project, Materials and Manufacturing Directorate scientists and engineers developed contacts and working relationships with researchers in the medical imaging community, the venture capital community, and the inventor/entrepreneurial communities in Ohio. These contacts help the directorate learn of new inventions and solutions, for transfer to the Air Force community, to solve expensive or difficult problems at minimum cost or disruption to traditional business practices.

Air Force Research Laboratory
Wright-Patterson AFB OH

Accomplishment

Directorate scientists invented, developed, patented, and licensed a vein viewing device that can see beneath the skin and through body sections to show the vasculature (the network of blood veins in the body) in a broad range of lighting conditions. The device dramatically shortens the time between occurrence of a wound and the IV administration of life-sustaining fluids—a factor that could save the lives of severely wounded soldiers as well as auto accident victims and trauma victims.

Due to the technology's potential for a broad range of civilian medical uses, the directorate established a Cooperative Research and Development Agreement with InfraRed Imaging Systems, Inc. of Columbus, Ohio. They will manufacture and market the technology to the medical industry and expand the technology to solve other critical medical challenges.

Background

The vein viewer device, which uses night vision goggles (NVGs) equipped with special filters developed by the Air Force, sees infrared light as it passes through a patient's body. Directorate scientists used a television remote control infrared light source and standard military NVGs to clearly detect the partial absorption of infrared light by blood in veins.

This device provides users with a clear view of the network of veins in fingers, hands, lower arms, and feet. Research showed that the capability to view veins is due to the absorption of infrared light by deoxygenated hemoglobin traveling in veins, while bone, muscle, and other tissue transmit or scatter the infrared light rather than absorbing it. Additional experiments proved that a needle beneath the skin would also be visible because metal blocks infrared light.

Directorate scientists demonstrated a prototype device at Wright-Patterson Medical Center, Cincinnati Children's Hospital Medical Center, and Columbus Children's Hospital, all in Ohio. Physicians involved in the demonstrations suggested the technology could be used effectively to alleviate a great deal of suffering by patients including infants, the elderly, and patients who must undergo painful medical procedures requiring repeated access to veins such as chemotherapy or dialysis.

Materials and Manufacturing
Technology Transfer

Additional information

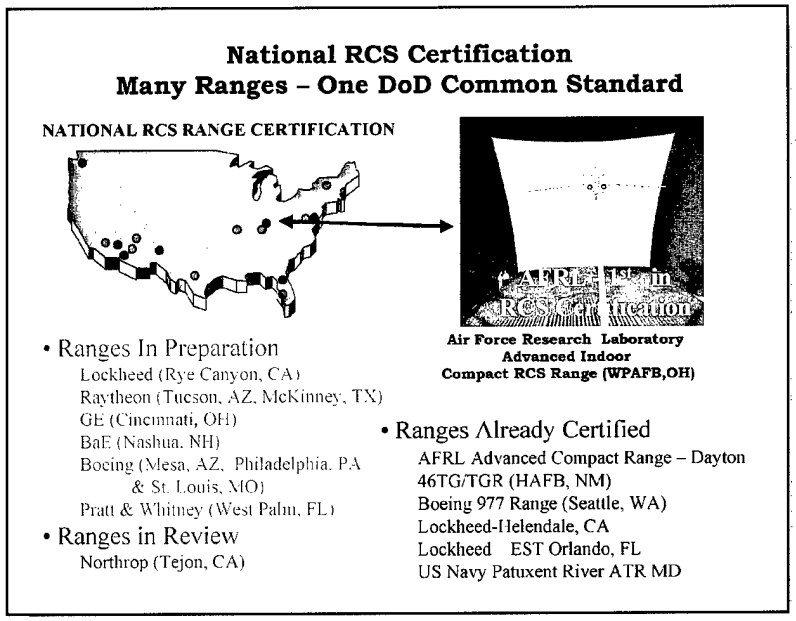
To receive more information about this or other activities in the Air Force Research Laboratory, contact TECH CONNECT, AFRL/XPTC, (800) 203-6451 and you will be directed to the appropriate laboratory expert. (03-ML-05)

Air Force Research Laboratory|AFRL

Science and Technology for Tomorrow's Air and Space Force

Success Story

REVOLUTION IN NATIONAL RADAR CROSS SECTION MEASUREMENT STANDARDIZATION BY SIGNATURE TECHNOLOGY OFFICE



Working in collaboration with the Department of Defense (DoD) Range Commanders Council, the United States (US) Navy and Army, the National Institute of Standards and Technology, the National Aeronautics and Space Administration, and academia, the Sensors Directorate's Signature Technology Office developed and implemented the first national calibration and measurement standardization process for DoD and industrial radar cross section (RCS) measurement facilities.

Based on the commercial American National Standards Institute (ANSI)-Z540 standard and demonstrated initially on the directorate's Advanced Compact Range, 6 of the approximately 20 major RCS test and evaluation sites in the US adopted this standard. The remaining sites are working for compliance by 2004.

Air Force Research Laboratory
Wright-Patterson AFB OH

Accomplishment

The directorate established baseline parameters for concrete and quantifiable calibration and measurement procedures for RCS facilities in the US, Canada, and the United Kingdom. This rigorous and methodical approach for establishing standard measurement processes helps commercial and DoD facilities deliver quantifiable and repeatable RCS data for a number of developmental weapon system programs, thereby reducing the risk and cost of inserting low-observable technology into common weapon systems.

Background

Prior to the implementation of the ANSI-Z-540 standard, minimal communication existed between national RCS facilities regarding quality of measurement. Since RCS measurements are a product of extremely complex electromechanical systems containing complex hardware and software subsystems, solving system-level problems was difficult without a standard for which to measure them and a forum to exchange ideas.

The directorate conceived a national certification program because it not only developed a standard in cooperation with its industry peers, but it also implemented a peer review system that assured the standard would be fairly and uniformly enforced. The certification process has three phases and normally takes 6 months to a year to complete depending on the quality of documentation maintained by the facility.

The directorate-developed standard, adopted as RCC Standard 804-01, calls for a 5-year migration plan. It will require US Government and industrial RCS ranges to comply with the standard for DoD contractors performing RCS measurements for the directorate.

Sensors
Technology Transfer

Additional information

To receive more information about this or other activities in the Air Force Research Laboratory, contact TECH CONNECT, AFRL/XPTC, (800) 203-6451 and you will be directed to the appropriate laboratory expert. (03-SN-01)